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# NINETEENTH ANNUAL REPORT

OF

# THE LOCAL GOVERNMENT BOARD,

# 1889–90.

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## SUPPLEMENT

CONTAINING THE

## REPORT OF THE MEDICAL OFFICER

**For 1889.**

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Presented to both Houses of Parliament by Command of Her Majesty.

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# ANNUAL REPORT

OF THE

# MEDICAL OFFICER

OF

# THE LOCAL GOVERNMENT BOARD

FOR THE YEAR

# 1889.

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# REPORT.

## TO THE RIGHT HONOURABLE CHARLES THOMSON RITCHIE, M.P., PRESIDENT OF THE LOCAL GOVERNMENT BOARD.



SIR,

Introduction.

IN the present Report, I have the honour to submit to you, to be laid before Parliament, an account of the proceedings of your Medical Department during the year 1889. The Report is in Supplement to the Nineteenth Annual Report of your Board.

Progress of Department.

The number of recorded references made to this Department for advice in matters relating to the Board's administrative business has amounted during the year to upwards of 6,000.

Sometimes at the Office, sometimes in the several localities, officers of the Medical Department have been entrusted with the duty of advising on the medical aspects of proposals for local byelaws, as well as for the provision of local hospitals, and other designs involving the borrowing of public money for local sanitary objects.

A much larger number of conferences between the Department and local authorities and officers have been held than in former years. Several such conferences have had concern for the administration of port sanitary districts.

Besides the many opportunities, of which the Medical Officer and Assistant Medical Officers gladly avail themselves, for giving aid and counsel to Medical Officers of Health who bring their difficulties to the Office, an extension of this sort of assistance has been made on several occasions during the year by local conferences between Medical Inspectors and Health Officers. The Department is thus able, in view of the actual circumstances, to place at the disposal of local authorities, through their officers, its own experience gathered from wider fields of observation.

Requests for advice from the Colonial and other Government Offices have also been received and complied with.

Incidentally I shall have occasion to advert to the Royal Commission on Vaccination, appointed in May 1889. And it will be my duty to record several important researches made for the Department with aid from the Parliamentary Grant for Auxiliary scientific investigations.

Medical Officer's Report.

# *I.—ADMINISTRATIVE RELATIONS OF THE MEDICAL DEPARTMENT.*

## 1. Vaccination and Public Vaccination.

Vaccination.

The digest of vaccination officers' returns (Appendix A., No. 1) has reference to the year 1887, and shows that out of the total children born in England and Wales during that calendar year, 7·1 per cent. had not, so far as the vaccination officers were aware, been successfully vaccinated at the date of their returns being made up, *i.e.*, on January 31st, 1889. Of this per-centage, 0·2 were recorded as having had vaccination attempted on them, but that the children were "insusceptible" to vaccination. The number of those certified to be in this case was 1,556; that is, one for every 472 certified as having been successfully vaccinated.

"Insusceptibility."

As with the amount of general default, so the number of certificates of insusceptibility given during the year was, in proportion to the population, greater in the metropolis than in the provinces. Indeed, in London, this so-called insusceptibility was found more than twice as often as in the rest of England. Within London itself there was to be found every variety in the frequency of such certification. While no such case was met with out of 3,994 children vaccinated in Shoreditch, in Fulham these certificates were given once for every 137 children submitted for operation. Upon inquiry being made by the Board from districts where such certificates were received in greatest profusion, it was almost invariably found that no certificate of the kind had been given by any public vaccinator. Certificates of insusceptibility, though they are not actually numerous, are showing tendency to increase; and in an appended memorandum (A., No. 2, page 19) I have directed attention to some of the considerations arising out of these documents.

Public vaccination.

The customary inspections of Public Vaccination have been made during the year 1889 by Inspectors of your Medical Department. The inquiries have extended to 273 unions, and have taken account of 1,263 vaccination districts (Appendix A., No. 3), and, with few exceptions, the vaccination arrangements have been found in satisfactory order:—898 recommendations for awards of money to public vaccinators have been made; the several officers having held their appointment for a twelvemonth or more, and having in all respects obeyed the instructions pertaining to their office.

There was no important change during the year among the Teachers and Examiners in Vaccination.

National Vaccine Establishment.

The supplies of humanized lymph have, as usual, been received by the National Vaccine Establishment from selected educational

and other stations, and have been submitted to the usual examination in the Establishment. The details of the supplies will be found in Appendix A., No. 4. Applications for this lymph amounted to 6,603.

National Vaccine Establishment.

Calf lymph was cultivated by Dr. Cory and the Assistant Director at the Board's Station at Lamb's Conduit Street, where, in addition to the 15,000 charged ivory points sent to the National Vaccine Establishment, 7,567 primary vaccinations of children were performed. The usual high degree of success attended the operations here; and particulars of these are appended (A., No. 5).

Vaccination Commission.

In May 1889 Her Majesty was pleased to appoint a Commission to inquire and report as to—

(1.) The effect of vaccination in reducing the prevalence of, and mortality from, small-pox.

(2.) What means, other than vaccination, can be used for diminishing the prevalence of small-pox; and how far such means could be relied on in place of vaccination.

(3.) The objections made to vaccination on the ground of injurious effects alleged to result therefrom; and the nature and extent of any injurious effects which do, in fact, so result.

(4.) Whether any, and, if so, what means should be adopted for preventing or lessening the ill effects, if any, resulting from vaccination; and whether, and, if so, by what means, vaccination with animal vaccine should be further facilitated as a part of public vaccination.

(5.) Whether any alterations should be made in the arrangements and proceedings for securing the performance of vaccination, and, in particular, in the provisions of the Vaccinations Acts with respect to prosecutions for non-compliance with the law.

This Commission held its first meeting on June 26th, and in August, after six meetings, issued a first report, comprising some evidence on the historical and statistical case in favour of vaccination. The Commissioners, on resuming their sittings in October, proceeded to take other evidence on this and further subjects of their inquiry; and have just issued a second report.

Alleged injuries.

In my last Annual Report to the Board I made mention of a circular issued by the Registrar-General to local registrars, at the instance of your Department, requesting these officers to transmit to your Board copies of all death-certificates in which vaccination was mentioned among the causes of death. Investigation has been made of each such case, and the result will be communicated to the Royal Commission. Besides the information thus received, certain complaints of injury alleged to be due to vaccination have been received from other sources, and have been investigated in the customary manner.

MEDICAL OFFICER'S REPORT.

## 2. OTHER ADMINISTRATIVE BUSINESS OF MEDICAL DEPARTMENT.

Small-pox in London and in England.

In a note to page vii of my Report of 1886, when considering the question of danger from *Small-pox Hospitals* to their neighbourhoods, I had occasion to say: "Further time is wanted "to show how far the duration of a small-pox epidemic in "London may be affected by the new plan of taking down to "Long Reach every case of small-pox that can possibly be "removed out of London." The time has not yet arrived for full study of this point; nor would it be safe to draw conclusions respecting the relation between this new plan and the prevalence of small-pox in London and, consequently, in England and Wales. But it is fitting that I should here put on record certain recent data as to small-pox mortality, along with the opinion now formed by the Metropolitan Asylums Board on the relation between the immunity of London from small-pox and the system of deportation inaugurated by that Board in 1884. In that and the following year a small-pox epidemic of ordinary London dimensions was in progress.

In continuation of the table on page 33 (Appendix A., No. 5) of my Report for 1884, I subjoin the yearly mortality from all causes and from small-pox in the Metropolis of the Registrar-General since the year 1884; the ratio of small-pox per 1,000 of total deaths, as well as the death-rate upon population, being also shown.*

| YEAR. | Deaths from all Causes. | Deaths by Small-pox. | Small-pox per 1,000 Deaths from all Causes. | Death-rate during successive Years from Small-pox per 1,000 Persons living. | |
|---|---|---|---|---|---|
| | | | | Year. | Death-rate. |
| 1885 - | 80,000 | 1,404 | 17·5 | 1885 | 0·34 |
| 1886 - | 82,276 | 24 | 0·3 | 1886 | 0·01 |
| 1887 - | 82,208 | 9 | 0·1 | 1887 | 0·00 |
| 1888 - | 78,848 | 9 | 0·1 | 1888 | 0·00 |
| 1889 - | 75,683 | 1 | 0·0 | 1889 | 0·00 |

The following is from the last two Annual Reports of the Chairman of the Metropolitan Asylums Board. The Reports

* For the purposes of this Table, all patients taken to the hospital-ships at Long Reach and dying there are reckoned to the account of the Metropolis.

Critical readers consulting the Report of 1884 may be reminded that up to and including 1880 the annual deaths recorded by the Registrar-General as "small-pox" included a score or two certified as being from "chicken-pox, cow-pox, and miliary fever." The data for 1881 onwards have reference only to deaths certified as from small-pox.

have reference to calendar years. 1888.—"Only 56 small-pox "patients have been admitted into the Board's hospitals during "the year 1887. The immunity of the inhabitants of London "from this type of infectious disease may not unfairly be at "least in part attributable to the prompt measures adopted by "the managers for the removal to the hospital ships at Long "Reach of the few cases which did occur in the Metropolis from "time to time during the year, and partly to the steps that were "taken by the several Medical Officers of Health to trace and deal "with the probable source of infection of each individual case." (*Minutes of Managers*, 1888–9, *p.* 159.) 1889. "Only five "cases of small-pox were admitted into the hospital ships at "Long Reach during 1889, which shows that the Metropolis "enjoyed special immunity from the disease, an immunity "which may be again ascribed to the prompt notification* of the "cases to the Medical Officers of Health for the districts from "which the patients were removed, and to their immediate "removal to, and isolation at, Long Reach." (*Minutes of Managers*, 1890–91, *p.* 80.)

Small-pox in London and in England.

In England and Wales, during the year 1889, the total mortality from small-pox recorded in the Registrar-General's quarterly returns was no more than 28 ; in a population of some 29 millions. Of these there were but seven small-pox deaths among the 9½ millions inhabiting the 28 great towns ; and of these seven there was but one single death from small-pox in the population of London, numbering over four millions.

---

Of 36 local inquiries made by Medical Inspectors during the year 1889 (*see* Appendix A., No. 6), 28 had reference to actual prevalence of epidemic disease of one and another kind, while the remaining eight involved questions of administrative action taken by the local authorities. In all, the sanitary circumstances of 52 districts were reported on by Inspectors of the Department. The occasion for inquiry into the prevalence of epidemic disease was usually given by a high mortality recorded in the Registrar-General's quarterly returns.

Local inspections.

In the ten outbreaks of "*Fever*" that gave rise to inspection by the Medical Department, the principal disease was always *Enteric Fever*, though in some instances another disease was found prevalent at the same time or shortly before ; this was sometimes scarlatina or diphtheria, and in the case of two northern colliery towns it had been *typhus* fever. The spread of enteric fever had been effected, in one place, by a particular

Inquiries about "Fevers."

* I do not find previous mention of notification. In fact, the Act requiring notification was not passed until August 30th, 1889, and did not come into force until two months later. The Asylums Board, however, had before these periods adopted a system of informing local Health Officers of small-pox cases admitted into the Board's Hospitals.

Enteric Fever inquiries.

milk-supply that had become infected with the poison of the disease; and in the rest the more usual methods of its distribution were observed. Both air and water were habitually found in these cases to be polluted by excremental filth, and between air and water it was often difficult to fix upon the precise means by which the fever material had been conveyed. The epidemic at Cradley, described by Dr. Gresswell in Appendix A., No. 7, gives an example of air and water being thus defiled by excrements in every possible way. In the great majority of cases, it was certain that the drinking water consumed by the inhabitants of the district had become dangerously polluted, and was in all probability the essential (perhaps the sole) means of fever spread.

In one most interesting instance, at Houghton-le-Spring (Appendix A., No. 8), there was good reason for believing that matters polluting a water-service had been carried along three-quarters of a mile in a fissure of magnesian limestone.*

Suspected public water-supplies.

It is not a little noteworthy that, among the instances where polluted waters were regarded by Medical Inspectors as having been more or less concerned in the production of enteric fever, suspicion attached, in no less than four instances, to waters furnished by public bodies for the common domestic supply of houses of the districts:—"supply drawn from river, which at "spring tides is polluted with sewage"; "public water-supply "insufficient; exposed, both before and after filtration, to risk "of contamination"; "fever limited to particular villages and "groups of dwellings within the area of supply"; "special "incidence of primary invasions on part of the town supplied "from a particular section of the public water service"—are reported to the Board by four Inspectors in respect of the several districts in question.

Diphtheria,

During the year, fourteen local inquiries on account of serious prevalence of *Diphtheria* have been made by the Department. These inquiries have as usual detected a variety of sanitary defects; but they have thrown no new light upon the obscurity which surrounds the local conditions concerned in diphtheria. Two reports on the subject (Appendix A., Nos. 9 and 10) illustrate, among other matters, a difficulty met with in these investigations, namely, the multiplicity of names that are given to diphtheria by medical practitioners.

In presenting to the Board in 1888 Dr. Longstaff's paper on "the Geographical Distribution of Diphtheria in England and Wales" during the 26 years 1855-80, I directed attention to the circumstance that, whereas this disease had always displayed a marked tendency to produce a higher mortality in sparsely

* Dr. Page's report on Houghton-le-Spring was the last of many accurate and luminous contributions to etiological research that the Department received from him during the six years that he served the Board. To the great sorrow of his fellow-workers, Dr. Page died in February of the present year, at the age of 44, having been on duty until a few days of his end.

Diphtheria.

populated districts than in populous towns, yet as the years advanced, urban districts had, as a whole, seemed to be approaching nearer than before to rural districts in their rate of suffering by diphtheria. Adverting in my Report for 1888 to this recent behaviour of diphtheria, I mentioned the illustration supplied by Norwich, and by Enfield and Walthamstow in the neighbourhood of London.

its growth in London.

Facts confirmatory of the foregoing observation have since been put on record for the metropolitan districts generally, by the Registrar-General in his Annual Summary of Causes of Death in London during 1889. After reporting a very large decline in the mortality from enteric fever during recent years, he continues—

"No similarly favourable account can be given of diphtheria, " the mortality from which disease had been increasing steadily " for many years, but in the last two years, 1888 and 1889, " made the most alarming bounds, the deaths rising from a " total of 953 in 1887, first to 1,311, and then in 1889 to no " less than 1,588, whereas the decennial average, after correc- " tion for growth of population, was only 932.

"This increase is so formidable that it may be well to give " the following table, in which are shown the numbers of deaths " from this disease for each of the past three years in each " sanitary area, the deaths in public institutions having been " distributed to the areas from which the patients had been " admitted.

"DEATHS from DIPHTHERIA in the METROPOLITAN SANITARY AREAS in the THREE YEARS 1887, 1888, and 1889, after Distribution of those occurring in Hospitals.

| Sanitary Area. | 1887. | 1888. | 1889. | Sanitary Area. | 1887. | 1888. | 1889. |
|---|---|---|---|---|---|---|---|
| Paddington - - | 29 | 76 | 42 | Bethnal Green - - | 27 | 52 | 102 |
| Kensington - - | 40 | 91 | 111 | Whitechapel - - | 6 | 24 | 34 |
| Hammersmith - - | 44 | 38 | 45 | St. George-in-the-East - | 15 | 15 | 43 |
| Fulham - - - | 19 | 10 | 12 | Stepney - - - | 14 | 25 | 47 |
| Chelsea - - - | 19 | 14 | 24 | Mile End Old Town - | 22 | 20 | 53 |
| St. George Hanover Square | 13 | 46 | 30 | Poplar - - - | 30 | 42 | 64 |
| Westminster - - | 25 | 37 | 28 | St. Saviour Southwark - | 8 | 13 | 12 |
| St. James Westminster - | 3 | 5 | 2 | St. George Southwark - | 12 | 23 | 20 |
| Marylebone - - | 14 | 23 | 34 | Newington - - | 27 | 18 | 55 |
| Hampstead - - | 13 | 16 | 8 | St. Olave Southwark - | 2 | 4 | 1 |
| Pancras - - - | 62 | 72 | 62 | Bermondsey - - | 16 | 14 | 23 |
| Islington - - - | 46 | 50 | 63 | Rotherhithe - - | 6 | 8 | 16 |
| Hackney - - - | 40 | 76 | 97 | Lambeth - - - | 105 | 107 | 156 |
| St. Giles - - - | 23 | 11 | 17 | Wandsworth and Battersea. | 51 | 92 | 77 |
| St. Martin-in-the-Fields - | 5 | 3 | 2 | | | | |
| Strand - - - | 10 | 3 | 8 | Camberwell - - | 65 | 64 | 70 |
| Holborn - - - | 9 | 5 | 17 | Greenwich - - | 37 | 34 | 30 |
| Clerkenwell - - | 17 | 26 | 24 | Lewisham - - - | 11 | 31 | 5 |
| St. Luke's - - - | 12 | 10 | 13 | Woolwich - - - | 3 | 3 | 6 |
| London City - - | 5 | 11 | 12 | Plumstead - - | 19 | 24 | 18 |
| Shoreditch - - - | 27 | 32 | 69 | | | | |

"It will be seen from this Table that in about half the areas " the deaths have gone up at least 50 per cent. since 1887, and " that in many of them they have been doubled, and in some " cases more than trebled, in that short period.

MEDICAL OFFICER'S REPORT.

"The mortality was above the decennial average throughout "the entire year, having only fallen in two weeks to the average "level; but its main excess was in the four months from the "middle of June to the middle of October."*

Scarlatina.

Three inspections were called for by local prevalences of *Scarlatina*. In two cases the spread of the disease appeared to be by the customary method of atmospheric infection and want of due isolation of the sick. In both these instances the inspectors record unusually high rates of fatality upon attacks, attributable perhaps to the foulness of the air in and about houses.† In the third case, investigated by Dr. Parsons (Appendix A., No. 12), scarlatina had been distributed in a particular milk supply among consumers living on the borders of the town of Macclesfield. A number of cases had occurred almost simultaneously in households supplied from one farm: the farmer, when the probable relation of his milk to the prevalent scarlatina was pointed out to him, lost no time in stopping the sale of his whole milk produce; and thus, thanks to him, the outbreak did not obtain very considerable dimensions. As regards the manner in which the infection of scarlatina was received into this milk, sufficient evidence was not, in this instance, forthcoming.

Measles in Potteries.

The Board directed inquiry in 1889 into an extensive and fatal prevalence of *Measles* that had for some months been infesting the Pottery districts of Staffordshire. Mr. Spear reporting on this epidemic has (Appendix A., No. 13), with some success, attempted to measure the operation of schools among the other influences fostering the disease. Examining one and another school area within the principal district infected by measles, the Inspector compares the local effect upon the epidemic produced by partial and by complete closure of the schools at various epochs of the epidemic. The history is instructive in other ways. It was not only in schools, but elsewhere throughout the districts, that there was lavish intercommunication between the sick and healthy; while want of air and ventilation in and about the dwellings of the people helped in the spread of infection. The exceptional rate of fatality among those attacked (a fatality which, indeed, had suggested

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* The Registrar-General adds:—"It is probable that some part of the increase "under diphtheria may be due to a diminution under the heading Croup, which in "accordance with the classification of the College of Physicians is separated from "diphtheria, and placed with the respiratory diseases. But this can only be a "partial explanation of the rise, which was far greater than the falling off under "croup. For the deaths from diphtheria and croup together amounted to 2,068 in "1889, while the decennial average, after due correction for increase of population, "would have been only 1,647."

† I place in Appendix A., No. 11, a report by an Inspector of the Department, on one of these outbreaks, principally for the sake of illustrating the fashion in which sanitary duty may be neglected in a district where the system prevails of appointing medical practitioners as Officers of Health on account of their already holding some other office.

that more than measles might be present in the Pottery towns) was shown to depend in chief measure upon the conditions under which children are bred and brought up in these districts.—Not zymotic diseases only, but with hardly an exception other classes of disease habitually swell the death-roll among children here. As compared with England and Wales, a typical Pottery district could, not long ago, show twice the infantile death-rate from lung diseases, more than twice the death-rate from convulsions, and four times the death-rates from consumptive and from cerebral diseases. Since the time when the mortality in these districts was investigated by Dr. Greenhow for the Privy Council, considerable, but necessarily gradual, efforts for sanitary improvement have been made in them. There still remains, however, a vast amount of work to be done by the sanitary authorities, and still more improvement to be obtained in the domestic and occupational circumstances of the people, before the high mortality among children shall be reduced, and a healthy race of men and women replace the present sickly folk of the Pottery districts.

Pottery districts.

Among the districts inspected by the Medical Department during the year, less because of their instant epidemics than in the hope of inducing their authorities to apprehend their ordinary sanitary interests, was the ancient city of Rochester. I invite special attention to Mr. Spear's report on this place. (Appendix A., No. 14.)

Rochester.

## § Foreign Epidemic.

On March 25th, 1889, the steamship "Atrato" arrived in Southampton from Brazil. Two deaths from *yellow fever* had occurred on the ship during the voyage, and accordingly by direction of the Port Sanitary Authority, the two cabins occupied by the deceased persons were fumigated, and also the hospital.—On the 2nd May the steamship "La Plata" arrived at Southampton from Brazil. Two deaths from yellow fever had taken place during the voyage, and accordingly, by direction of the Port Sanitary Authority, the cabins occupied by the patients were fumigated.—On June 13th the steamship "Neva" arrived at Southampton from Brazil. Two deaths from yellow fever had occurred during the voyage, and one just before arrival at Southampton; one patient ill of so-called Brazilian fever was found on the ship. Accordingly the vessel was put into quarantine at the Motherbank, and thenceforth the vessel and her passengers were subject to the orders of Her Majesty's Privy Council. Dr. Blaxall was instructed by your Board to learn and record the experience of the vessel and her passengers; and I append (Appendix A., No. 15) extracts from his report on the case.

Yellow fever.

No case of yellow fever occurred among the population of Southampton during the year.

## *II.—AUXILIARY SCIENTIFIC INVESTIGATIONS.*

Pathology of Diphtheria.

(1.) The most important research of last year was by Dr. Klein (Appendix B., No. 1), in continuation of that study of *Diphtheria* to which I briefly referred in my Annual Report for 1888. Dr. Klein has been materially assisted in his laboratory researches by what I may call (for contradistinction's sake) the *field-observations* about the causation of diphtheria, made by Inspectors of my Department; and in return he contributes from his laboratory some precise information about the pathology, and especially the comparative pathology of the disease, available for future field-investigation into the ways of diphtheria in man.

A diphtheria bacillus.

Dr. Klein reports that by the application of improved methods for the separation of microbes occurring in superficial layers from those peculiar to the deeper portions of diphtheria membrane, he has succeeded in recognizing one particular bacillus which is constantly present in every membrane of diphtheria, and in identifying it from among others that are only occasionally present there.

Of the occasionally observed bacilli, one in particular, which is relatively frequent in the superficial layers of diphtheria membranes, and which may also be found at times in healthy mucous membranes, has little morphological difference from the bacillus which is constant; and these two forms had, it would appear, been confounded together under a common name as "Klebs-Löffler" bacilli. But now Dr. Klein has recognised that the two forms, besides having minor morphological differences, differ significantly in their conditions of growth. The one grows, he tells us, at temperatures where the other refuses to grow; accordingly they differ as to growth upon solid gelatine; and, notably, they also behave in very dissimilar ways, the one from the other, when milk is used as the nutrient medium. With these means of discriminating between the constant and the inconstant form of the Klebs-Löffler bacillus, and of thus isolating the former for experimental purposes, Dr. Klein appears to have demonstrated absolutely a specific bacillus which is necessarily present in diphtheria.*

Inoculations with diphtheria materials.

The view which Dr. Klein takes of the relation of his bacillus to this disease is based upon significant pathological observations and experiments. These he began by inoculations of diphtheria material into rodents, because these creatures are most usually employed in the pathological laboratory. But though he frequently got pronounced disease in rodents, he did not produce anything like diphtheria in them, nor did he get from them any uniform and distinctive symptoms, such as he wanted for his

* Dr. Klein is no doubt content to pass over at this time any consideration of possible development of his bacillus from or into another bacterial organism. Enough for his purpose that he identifies a certain thing by qualities special to itself, such qualities including a constant and intimate relation to diphtheria, and that he has no suggestion of any development or transmutation to record.

purposes. His further experimental inoculations were therefore made upon cats, his selection of these animals having been determined by the considerations mentioned in my Report (p. viii.) of last year. Dr. Klein found that diphtheria membrane of human origin inoculated into the cat gave rise to morbid conditions remarkably similar to that which he had seen in cats sent to him from diphtheria households; conditions, especially as witnessed in the kidney and in the cornea, which could be reproduced by subsequent inoculations of successive cats, and which possessed such diagnostic signs as he desired to have. From this point he proceeded to study the relation of bacterial forms found in diphtheria membranes to animal disease artificially induced. His results thus far are sufficiently striking.

Inoculations with diphtheria materials.

The bacillus distinguished by Dr. Klein from among other Klebs-Löffler bacilli, when grown by itself on artificial media, is found able to produce, as no other bacterium produces, those definite characteristics of diphtheria that result from direct inoculation of the cat with the material of human diphtheria.—The cat-disease thus set up is able to infect with the same disease other cats kept in the same cage.—From this cat-disease bacilli can be recovered in their turn by new subcultures on artificial media; and these bacilli prove to be, in their form and in the peculiarities of their growth identical with the original bacilli taken from the human diphtheria membrane.—Dr. Klein would represent the chain of evidence, connecting these bacilli with diphtheria as cause and effect, as being complete except for the absence of fore-ordained experiment upon the human subject. So the missing link of the chain is only furnished by inference, viz., from the instances above mentioned, where cats suffering under some ailment of their own have been accused with more or less probability of bringing diphtheria into households.

Inoculations with bacterial growths.

With evidence of the foregoing kind before him, Dr. Klein found himself in a position to begin an inquiry into the behaviour of milch cows towards diphtheria; an inquiry that was needed by the Department with a view to the better understanding of those local epidemics of diphtheria which Medical Inspectors had found to prevail from time to time in connexion with milk supplies. The following is a short account of Dr. Klein's investigations.

Effect upon milch cows.

Two milch cows, in good health, inoculated subcutaneously at their shoulders with broth subcultures of diphtheria bacilli derived from a human subject, showed a swelling at the place of inoculation, beginning on the third day, increasing in size during the first week, and then becoming smaller. One of these cows, in the course of the second week, and the other in the course of the fourth week, became seriously ill, being until then in seemingly good health and yielding abundant milk: one died on the 15th day, the other was killed on the 25th day. Besides serious changes in the organs observed post-mortem, the tumours

Diphtheria inoculations.

at each spot of inoculation were examined, and material was taken from them for microscopic and pathological study.—The bacilli of diphtheria were found to have multiplied abundantly at the spot of inoculation, and these, transplanted into nutrient media, were able to form there colonies of the same bacillus diphtheriæ, free from other forms of bacteria.

It remains to tell the phenomena of the milk apparatus and of the milk in the two inoculated cows.

Effects on skin, of milch cows,

On the fourth day in one cow, and about the same day in the other, while the cows were to an ordinary observer well and giving plenty of milk, small vesicles made their appearance on the cows' udders, and these rapidly passed into pustules and crusted ulcers. Afterwards similar vesicles running the same course were found on one or more teats of each cow. Dr. Klein gives good reason, first, for believing that these sores were not the result of any accident, nor of the process of milking; and, secondly, for regarding the sores as really being local manifestations of a constitutional disease induced by the diphtheria inoculation.—He then examines the lymph of the induced vesicles and pustules; and here "the bacillus diphtheriæ could be "demonstrated unmistakeably both in cover-glass specimens and "by culture."

and of calves.

Next, with matters taken from the udder vesicles and pustules, on the day after the eruption had appeared on one of the inoculated cows, Dr. Klein proceeded to the inoculation of two calves. The calves showed at the spots of inoculation, vesicles and pustules, similar to those of the cows themselves; the calves fell ill, were killed on the 25th day, and exhibited post-mortem appearances like those found in the cows.

Effect upon milk.

Now, as to the milk of the inoculated cows:—On the fifth day, from a healthy teat, carefully guarded against the introduction of accidental matter from the surface, milk was drawn into a sterilized beaker, and a drop (taken with all befitting precautions) was spread on the surface of nutrient gelatine. In three out of four tubes of this gelatine, bacterial colonies formed after the expected interval. There were eight colonies in all. All of these eight, Dr. Klein reports, were "unmistakeably colonies of the bacillus diphtheriæ." There were no other organisms present.

Finally, Dr. Klein records an outbreak of his cat-diphtheria, beginning with two cats, that had been supplied with milk from one (or both) of the inoculated cows. This incident was not ordained beforehand, and was the consequence of violation of orders: it therefore lacks the precision wanted in an intentional experiment.*

* Very delicate microscopical drawings, in illustration of Dr. Klein's paper on Diphtheria, were made by Mr. Lapidge and others, under Dr. Klein's direction. Photographs were also prepared showing the peculiarities of the bacterial forms considered in the text of Dr. Klein's report.

Many of these drawings and photographs, as they are reproduced in the Appendix, are practically worthless for their purpose. Yet they are second attempts made by the lithographers; and upwards of four months have been spent in the production and reproduction of the professing illustrations to Dr. Klein's essay.

Concurrent Infections.

(2.) Dr. Klein has further contributed to the present Report (Appendix B., No. 2) a paper on *Concurrent Inoculation of Different Infections*. Clinical observations have long ago shown that one infective process may exert some sort of modifying influence upon another infective process, when the one accompanies or follows closely upon the other in a given animal body: and since we have obtained better knowledge of the nature of these processes, some direct experiments have shown that certain bacteria operate in antagonism to each other, both when they are growing in living bodies and when they are multiplying themselves in artificial media. Conversely, Dr. Klein's inquiries of this year (confirming and extending some observations by Monti) have exhibited instances of bacterial products which operate to prepare, as it were, the living tissues for the reception of toxic bacteria in such a way as to enhance the proper pathogenic qualities of those latter. The subject is a large and difficult one. It has an important bearing on the differing "predisposition" of different individuals to attacks of a particular infection, and also on the differing intensity of the resulting disease experienced by different individuals. On these accounts, as well as for other practical uses of such knowledge in my Department, it is proposed to extend Dr. Klein's investigation of this subject.

Food poisoning.

(3.) I have next to mention an interesting observation made by Dr. Klein during the past year (Appendix B., No. 3). It related to one of those remarkable cases of *Food Poisoning* that come from time to time under the notice of the Medical Department. Circumstantial evidence had shown a connexion between a smart diarrhœal outbreak at Carlisle and the consumption of pork and pork-pies. Specimens of the pork, and also of certain gravy-stock that had entered into the composition of the pork-pies, were sent to Dr. Klein for examination. He fed mice upon these materials and produced disease in the intestines and in the lungs of the animals. The lungs contained a particular form of bacillus; and this bacillus was out of a variety of other bacterial forms presently identified in the gravy-stock. Taken from the one or the other source, indifferently, the bacillus could be cultivated on an appropriate nutrient medium; and the subcultures grown from the bacilli of the mouse's lung were found to have the same toxic property as the original gravy-stock:—inoculation or feeding of other mice with these subcultures, giving rise to the same intestinal and lung disease as in the previous mice; with bacilli, capable of fresh cultivation, characterizing the newly induced lung disease.

The phenomena that we speak of as "food poisoning," productive now of one and now of another sort of definite malady among consumers of certain foods, are claiming, on ever-growing evidence, to be regarded as true infective diseases, as much so as scarlatina or tuberculosis. That they have not been generally admitted into this rank arises, first, from the

circumstance that some of them have seemed to be wanting in an incubation period; and secondly, because they are rarely recognized as transmissible from person to person. But, from our researches of this very year, we derive some new considerations that materially affect the importance of "incubation" as determining the infective nature of a poison; while we need go no further than the experiences of Middlesbrough in 1888 to find suggestion of disease-bacteria operating alternatively through the atmosphere and through infection of food-material by them.

Bacteria and Digestive processes.

(4.) Dr. Vincent Harris's researches of 1888 have been continued during the subsequent year (Appendix B., No. 4). They consist in observations as to the *Relations of Bacteria with Digestive Processes.* In a previous Report, Dr. Harris described the bacterial forms seen in the healthy stomachs of certain rodents; and he went on to experiment with various animals of this class as to the influence of their digestive processes upon anthrax bacilli *free from spores.* These spore-free bacilli, introduced along with food into the stomach of the test rodents, were not found in the intestines; they could not be obtained by culture experiments with the intestinal mucus. Dr. Harris, in his present Report, records observations on similar rodents fed with *spore-bearing* anthrax bacilli; and now he tells of active bacilli recoverable by culture experiments from the contents of the intestine; the spores therefore having resisted the action of the gastric juice that was destructive to anthrax bacilli in their spore-free form.

The distinction which thus appeared has proved the occasion for a diversion from the immediate thesis of the research. The gastric juice of these rodents has been considered as forming, inferentially, a test of the presence or absence of spores in general, a test that could be applied to tubercle bacilli and other bacillar forms where spores had not been otherwise identified. The remainder of Dr. Harris's inquiry in 1889 was concerned with this collateral but interesting issue.

Chemistry of bacterial growth.

(5.) In my last Report I made mention of a design, which afterwards received your approval, to proceed further in our studies of those chemical *Changes which Organic Substances undergo while supplying means of growth to Bacterial Organisms* contained in them. Studies of this kind have been made aforetime, now by chemists, now by bacteriologists, but seldom by investigators who were conversant alike with the higher branches of chemistry and with the niceties and significances of bacteriology.

Our own more particular investigation of the subject dates from 1883, when Dr. Burdon Sanderson, reporting as to chemical agents capable of destroying the material of infection, dwelt upon the circumstance that many of the chemical products of bacterial life are endowed in a very remarkable degree with the power of putting an end to the life of bacteria themselves. A further line of investigation of the subject was begun for

Chemistry of bacterial growth.

the Department in 1885, when Dr. Wooldridge, experimenting with a septicæmic bacillus upon a solution of vegetable albumen, obtained a toxic substance which he regarded as of proteid nature. In 1886, the same observer, growing anthrax bacilli upon certain prepared animal fluids, obtained a chemical substance or chemical substances which, when injected into the circulation of an animal susceptible to anthrax, conferred (so far as his experiments went) immunity against the effect of anthrax inoculated simultaneously into the animal. Next year we ourselves lost Dr. Wooldridge's assistance, and in 1889, pathological science had to deplore his death. Last year an excellent synopsis of the current literature of the metabolic products of bacterial life was contributed to my Report by Dr. McFadyen, and now the study of the subject has been resumed for the Department by Dr. Sidney Martin (Appendix B. No. 5).

Dr. Martin has undertaken to grow *anthrax bacilli*, under recorded conditions, in a medium prepared from the simplest unorganized materials he could devise in imitation of the serum of blood, its proteid and salts; and to observe the chemical changes worked upon this medium by the bacilli at one and another stage of their growth. His scheme was to separate such chemical substances as presented themselves, to investigate the chemical nature of each, and at the same time to make use of each (always after due separation from the bacilli themselves) in the inoculation of mice. In the event, Dr. Martin announces successive stages in the conversion of his proteid into other, more or less chemically definable, proteid substances; his observation thus far yielding results similar to those attained by Dr. Wooldridge. But also, and apparently in further sequence to the foregoing changes, Dr. Martin produces, by a more continued growth of anthrax bacilli upon the same medium, an alkaloid which forms readily crystallizable salts. This alkaloid remains for more precise chemical investigation. Meanwhile, however, both the new proteids ("anthrax albumoses") and the alkaloid have been tested on mice, with the result of producing disease in them. The resulting phenomena have seemed to be identical with those following the inoculation of anthrax bacilli themselves; though, upon the death of the animal, no anthrax bacilli are to be found in the organs.—For the production of these disease phenomena, the anthrax albumoses and the anthrax alkaloid have had to be used in some considerable quantity. It has not been enough, as in the case of inoculation with bacilli, that a quite inappreciable amount of the toxic substance be introduced into the body. Moreover, the anthrax alkaloid, when it has acted harmfully upon the experimental animals, has operated with great rapidity, very much in the manner of an unorganized chemical poison: the anthrax albumoses have operated with less rapidity, but still without showing any such lapse of time as is witnessed between the inoculation of living anthrax bacilli and the appearance of the characteristic symptoms of anthrax disease.

Observations have not yet been made (on Dr. Wooldridge's lines) as to any protection against anthrax, conferred upon animals by Dr. Martin's chemical products.

(6.) No progress has been made in the investigation of the micro-organisms of plumbo-solvent waters; but it is hoped during the ensuing year to enter on the subject afresh, with the aid of local observations, as well as of laboratory experiments.

I have the honour to be,
Sir,
Your obedient servant,
GEORGE BUCHANAN.

August 30th, 1890.

# APPENDICES.

# APPENDICES.

## APPENDIX A.

### No. 1.

DIGEST of the VACCINATION OFFICERS' RETURNS, with regard to CHILDREN whose BIRTHS were registered in the Year 1887.

App. A. No. 1.
Digest of Vaccination Officers' Returns.

THE following is the sixteenth annual return under the Vaccination Act, 1871. Of 886,198 births returned to the Board by the several Vaccination Officers in England and Wales as registered during the year 1887, the number which at the time the return was made had been registered as successfully vaccinated was 733,980. This number is 82·8 per cent. of the whole. The children whose births were registered during the year, and who were not recorded as successfully vaccinated, numbered 152,218. Of this number, 87,827 were registered as having died unvaccinated.* Out of the same number, 1,556 had been registered as insusceptible of vaccination; 27 as having contracted small-pox and, therefore, not needing to be vaccinated; 10,402 as having their vaccination postponed by medical certificate; and there remained on the Vaccination Officers' registers 52,406 children born in 1887, who had "removed," were "not to be traced," or were otherwise unaccounted for. If from the 886,198 births returned by these officers deduction of the deaths without vaccination be first made, it appears that of the remaining 798,371 children, there were registered at the time of the return 91·9 per cent. as successfully vaccinated; 0·2 per cent. as either insusceptible of vaccination, or as having had small-pox; and 1·3 per cent. as under medical certificate of postponement; leaving 6·6 per cent. as at that time still unaccounted for as regards vaccination.

The per-centages of children not finally accounted for as regards vaccination (*i.e.*, including cases postponed) was 7·1 of the total births (886,198); and this figure is given in the table following, in sequence to the records of former years.

By the latter method of computation, it appears that the proportion of cases not finally accounted for in the metropolitan returns for 1887 was 9·0 per cent.; in the provincial returns, 6·7. Of the registered births of the sixteen years 1872–87, the corresponding proportion not finally accounted for in regard to vaccination in each year respectively has been as follows:—

| Year. | Metropolis. | Rest of England. | Year. | Metropolis. | Rest of England. |
|---|---|---|---|---|---|
| 1872 | 8·8 | 4·5 | 1880 | 7·0 | 4·5 |
| 1873 | 8·7 | 4·2 | 1881 | 5·7 | 4·3 |
| 1874 | 8·8 | 4·1 | 1882 | 6·6 | 4·5 |
| 1875 | 9·3 | 3·8 | 1883 | 6·5 | 4·9 |
| 1876 | 6·5 | 4·0 | 1884 | 6·8 | 5·3 |
| 1877 | 7·1 | 4·1 | 1885 | 7·0 | 5·5 |
| 1878 | 7·1 | 4·3 | 1886 | 7·8 | 6·1 |
| 1879 | 7·8 | 4·5 | 1887 | 9·0 | 6·7 |

* Of vaccinated children, dying before the returns are made up, no record is kept; but see note overleaf.

App. A. No. 1, Digest of Vaccination Officers' Returns.

| | Metropolis. | Rest of England. |
|---|---|---|
| Average of 5 years, 1873–77 - | 8·1 | 4·1 |
| „ „ 1878–82 - | 6·8 | 4·4 |

In 1887, the proportion of cases unaccounted for, after deduction of the postponed cases, in the metropolis and in the rest of England, was 7·9 and 5·6 per cent. respectively.

*Note by the Medical Officer.*

As in my last two annual Reports, I am desirous of calculating, upon such data as are available, the number of children who, at the time the Vaccination Officers' Returns are made up, pass into the vaccinated class of the population, and the number that pass into the unvaccinated class. The result expressed in per-centages of the two classes cannot, I know, be absolutely correct; but I have satisfied myself that it cannot differ from the truth by more than a fraction of a unit per cent.

Vaccination Officers' Returns are made up to January 31st of the year but one following that to which returns relate. The interval between birth and return must therefore always be a twelvemonth and something more. This "something more" may be as little as one month, or as much as 13 months, according as the child is born at the beginning or the end of a calendar year:—the mean of the one and 13 months is seven months. [The following has reference to the Returns now presented.]

Let us as a first step examine the total mortality so far as recorded by the Registrar-General for the above period of childrens' lives, and apply our examination to the case of children born in 1887. We may take as a fair approximation to the mortality of children born in 1887 and dying during the first twelvemonth of life, the mean mortality at ages 0–1 of the years 1887–88; namely, 124,178.

We may take as a fair approximation to the mortality of children born in 1887, surviving their first year and dying in the course of 1–13 months afterwards, seven-twelfths of the mortality at ages 1–2 of the year 1888; namely: $\frac{7}{12} \times 36{,}814 = 21{,}475$.

The sum of the two figures 124,178 and 21,475 (viz.:—145,653) represents then with sufficient accuracy the total mortality occurring up to January 31st, 1889, among the children born in 1887. But the births of 1887 numbered 886,198, and therefore there remains a balance of 740,545 children, vaccinated and unvaccinated together, born in 1887 and surviving January 31st, 1889.

As a second step let us examine the returns of the Vaccination Officers made up to January 31st, 1889, and relating to the births of 1887. We find there a record of 87,827 deaths known to have occurred among unvaccinated children.

We find from the same returns a number of children born in 1887, and recorded as neither dead nor vaccinated on January 31st, 1889. The number of these unvaccinated survivors at the date in question was 64,391.

The difference between the total survivors and the unvaccinated survivors represents the number of children born in 1887 who, having been vaccinated, survived January 31st, 1889, the date to which Vaccination Officers' returns for 1887 are made up. This number is 676,154; vaccinated survivors.

[These numbers no doubt may deviate a little on one or the other side, from the precise number of deaths and survivals; but the deviations cannot be very large, and some of them would seem compensatory of each other.]

On February 1st, 1889, therefore the survivors of those born in 1887 were pretty closely as follows:—

| | | |
|---|---|---|
| Vaccinated children - - - | 676,154 | 740,545 |
| Unvaccinated children - - | 64,391 | |

or, per cent. of all survivors,

| | |
|---|---|
| Vaccinated children - - - - | 91·3 |
| Unvaccinated children - - - - | 8·7 |

[I have said "pretty closely"; and a judgment may be formed of the extent of any probable error by noting that the transfer of 1,000 from the one to the other number would alter the respective per-centages by less that a quarter per cent.]

This per-centage 8·7 is made up of—

0·21 per cent. (1,583) certified as insusceptible of vaccination or as having already had small-pox.

1·4 „ (10,402) vaccination postponed by medical certificate.

7·08 „ (52,406) unaccounted for.

G. B.

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| ENGLAND & WALES - | 886,198 | 733,980 | 1,556 | 27 | 87,827 | 10,402 | 52,406 | 7·1 |
| Ditto (excluding Metropolitan Unions). | 752,879 | 626,486 | 1,135 | 27 | 74,437 | 8,885 | 41,909 | 6·7 |
| METROPOLITAN UNIONS - | 133,319 | 107,494 | 421 | — | 13,390 | 1,517 | 10,497 | 9·0 |
| COUNTIES. | | | | | | | | |
| ENGLAND: | | | | | | | | |
| Bedford - - - | 4,894 | 3,632 | 4 | — | 549 | 128 | 581 | 14·5 |
| Berks - - - | 7,700 | 6,626 | 16 | — | 637 | 194 | 227 | 5·5 |
| Bucks - - - | 4,831 | 4,206 | 4 | — | 449 | 43 | 129 | 3·6 |
| Cambridge - - | 5,721 | 5,007 | 8 | — | 512 | 66 | 128 | 3·4 |
| Chester - - - | 20,364 | 17,733 | 35 | 2 | 1,907 | 176 | 511 | 3·4 |
| Cornwall - - - | 8,906 | 7,525 | 11 | 1 | 943 | 128 | 298 | 4·8 |
| Cumberland - - | 8,193 | 7,060 | 5 | — | 793 | 136 | 199 | 4·1 |
| Derby - - - | 13,366 | 11,336 | 20 | — | 1,275 | 147 | 588 | 5·5 |
| Devon - - - | 17,621 | 15,263 | 29 | — | 1,521 | 276 | 532 | 4·6 |
| Dorset - - - | 5,291 | 4,668 | 4 | — | 374 | 70 | 175 | 4·6 |
| Durham - - - | 34,952 | 29,136 | 36 | — | 3,753 | 399 | 1,628 | 5·8 |
| Essex - - - | 22,803 | 19,000 | 53 | — | 2,049 | 366 | 1,335 | 7·5 |
| Gloucester - - | 15,804 | 12,737 | 42 | — | 1,363 | 168 | 1,494 | 10·5 |
| Hereford - - - | 3,130 | 2,763 | 6 | — | 246 | 45 | 70 | 3·7 |
| Herts - - - | 7,238 | 6,258 | 14 | — | 623 | 75 | 268 | 4·7 |
| Huntingdon - - | 1,462 | 1,336 | 2 | — | 85 | 12 | 27 | 2·7 |
| Kent (extra-metrop.) - | 23,294 | 20,085 | 42 | — | 1,998 | 211 | 958 | 5·0 |
| Lancaster - - | 128,746 | 104,655 | 228 | 1 | 14,079 | 1,604 | 8,179 | 7·6 |
| Leicester - - - | 11,954 | 6,101 | 9 | — | 1,766 | 90 | 3,988 | 34·1 |
| Lincoln - - - | 14,110 | 11,948 | 18 | 4 | 1,546 | 178 | 416 | 4·2 |
| Middlesex (ex.-metro.) | 14,828 | 12,125 | 37 | — | 1,321 | 151 | 1,194 | 9·1 |
| Monmouth - - | 8,823 | 7,625 | 3 | — | 804 | 119 | 272 | 4·4 |
| Norfolk - - - | 13,673 | 11,636 | 21 | — | 1,318 | 202 | 496 | 5·1 |
| Northampton - - | 9,176 | 6,921 | 11 | — | 968 | 102 | 1,174 | 13·9 |
| Northumberland - | 16,187 | 13,770 | 19 | — | 1,730 | 260 | 408 | 4·1 |
| Nottingham - - - | 17,058 | 13,874 | 28 | — | 1,862 | 141 | 1,153 | 7·6 |
| Oxford - - - | 5,501 | 4,668 | 9 | — | 436 | 76 | 312 | 7·1 |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| COUNTIES—*cont.* | | | | | | | | |
| England—*cont.* | | | | | | | | |
| Rutland | 614 | 539 | 2 | — | 55 | 5 | 13 | 2·9 |
| Salop | 7,290 | 6,444 | 6 | — | 579 | 84 | 177 | 3·6 |
| Somerset | 24,598 | 12,515 | 19 | — | 1,225 | 282 | 557 | 5·7 |
| Southampton | 19,011 | 16,474 | 29 | 1 | 1,536 | 270 | 701 | 5·1 |
| Stafford | 31,992 | 26,967 | 42 | — | 3,454 | 268 | 1,261 | 4·8 |
| Suffolk | 11,118 | 9,632 | 18 | — | 876 | 161 | 431 | 5·3 |
| Surrey (extra-metro.) | 14,727 | 12,766 | 24 | — | 1,099 | 160 | 678 | 5·7 |
| Sussex | 14,270 | 12,092 | 19 | — | 1,130 | 239 | 790 | 7·2 |
| Warwick | 24,321 | 20,265 | 43 | — | 2,516 | 187 | 1,310 | 6·2 |
| Westmorland | 1,811 | 1,660 | 1 | — | 129 | 12 | 9 | 1·2 |
| Wilts | 7,268 | 6,357 | 1 | — | 601 | 115 | 194 | 4·3 |
| Worcester | 18,033 | 15,671 | 27 | — | 1,793 | 144 | 398 | 3·0 |
| York, East Riding | 12,430 | 10,236 | 34 | — | 1,335 | 99 | 726 | 6·6 |
| York, North Riding | 11,016 | 9,523 | 14 | — | 1,028 | 146 | 305 | 4·1 |
| York, West Riding | 73,615 | 58,398 | 113 | 17 | 8,019 | 612 | 6,456 | 9·6 |
| Wales: | | | | | | | | |
| Anglesey | 932 | 809 | — | — | 86 | 10 | 27 | 4·0 |
| Brecknock | 1,607 | 1,423 | — | — | 154 | 11 | 19 | 1·9 |
| Cardigan | 1,782 | 1,602 | — | — | 117 | 33 | 30 | 3·5 |
| Carmarthen | 3,946 | 3,500 | 2 | — | 322 | 71 | 51 | 3·1 |
| Carnarvon | 3,227 | 2,838 | 1 | — | 297 | 29 | 62 | 2·8 |
| Denbigh | 2,533 | 2,169 | 4 | — | 256 | 52 | 52 | 4·1 |
| Flint | 2,383 | 2,078 | 1 | — | 201 | 30 | 73 | 4·3 |
| Glamorgan | 21,780 | 18,788 | 20 | 1 | 2,073 | 185 | 713 | 4·1 |
| Merioneth | 1,838 | 1,617 | — | — | 183 | 20 | 18 | 2·1 |
| Montgomery | 1,903 | 1,676 | 1 | — | 171 | 23 | 32 | 2·9 |
| Pembroke | 2,701 | 2,322 | — | — | 257 | 60 | 62 | 4·5 |
| Radnor | 507 | 431 | — | — | 38 | 14 | 24 | 7·5 |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| METROPOLITAN UNIONS. | Returns, 1887. | | | | | | | | *Ratio of Insusceptible to attempted Vaccination.* |
|---|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. | |
| Bethnal Green | 5,001 | 3,741 | 10 | — | 576 | 60 | 614 | 13·5 | *1 : 375* |
| Camberwell | 7,460 | 6,005 | 27 | — | 728 | 104 | 596 | 9·4 | *1 : 223* |
| Chelsea | 3,209 | 2,605 | 12 | — | 360 | 16 | 216 | 7·2 | *1 : 218* |
| Fulham | 5,813 | 4,932 | 36 | — | 580 | 49 | 216 | 4·6 | *1 : 137* |
| George, St., Hanover Sq. | 3,300 | 2,810 | 9 | — | 330 | 31 | 120 | 4·6 | *1 : 313* |
| George St., in the East | 1,869 | 1,490 | 2 | — | 252 | 1 | 124 | 6·7 | *1 : 745* |
| Giles, St., and St. George | 1,228 | 952 | 2 | — | 101 | 25 | 148 | 14·1 | *1 : 476* |
| Greenwich | 5,319 | 4,265 | 19 | — | 525 | 116 | 394 | 9·6 | *1 : 225* |
| Hackney | 6,609 | 5,326 | 33 | — | 663 | 74 | 513 | 8·9 | *1 : 162* |
| Hampstead | 1,397 | 1,222 | 7 | — | 98 | 5 | 65 | 5·0 | *1 : 175* |
| Holborn | 5,311 | 4,233 | 6 | — | 12 | 16 | 444 | 8·7 | *1 : 706* |
| Islington | 9,732 | 7,769 | 44 | — | 1,133 | 171 | 615 | 8·1 | *1 : 177* |
| Kensington | 3,958 | 3,303 | 14 | — | 364 | 33 | 244 | 7·0 | *1 : 236* |
| Lambeth | 9,129 | 7,161 | 31 | — | 924 | 66 | 947 | 11·1 | *1 : 231* |
| Lewisham | 2,329 | 1,985 | 14 | — | 179 | 26 | 125 | 6·5 | *1 : 142* |
| London, City of | 792 | 648 | 1 | — | 80 | 6 | 57 | 8·0 | *1 : 648* |
| Marylebone | 4,771 | 4,076 | 4 | — | 466 | 44 | 181 | 4·7 | *1 : 1,019* |
| Mile End Old Town | 3,967 | 3,105 | 11 | — | 402 | 39 | 410 | 11·3 | *1 : 283* |
| Olave, St. | 5,038 | 3,637 | 11 | — | 499 | 169 | 722 | 17·7 | *1 : 331* |
| Paddington | 2,915 | 2,440 | 11 | — | 220 | 40 | 204 | 8·4 | *1 : 222* |
| Pancras, St. | 7,546 | 6,169 | 22 | — | 698 | 46 | 611 | 8·7 | *1 : 281* |
| Poplar | 5,992 | 5,070 | 21 | — | 559 | 26 | 316 | 5·7 | *1 : 242* |
| Saviour, St. | 7,256 | 5,019 | 9 | — | 860 | 24 | 1,344 | 18·9 | *1 : 558* |
| Shoreditch | 4,695 | 3,994 | — | — | 437 | 21 | 243 | 5·6 | *1 : ∞* |
| Stepney | 2,063 | 1,709 | 7 | — | 237 | — | 110 | 5·3 | *1 : 245* |
| Strand | 617 | 486 | 1 | — | 70 | 18 | 42 | 9·7 | *1 : 486* |
| Wandsworth and Clapham | 9,154 | 7,335 | 37 | — | 815 | 244 | 723 | 10·6 | *1 : 199* |
| Westminster | 971 | 774 | 3 | — | 111 | 5 | 58 | 8·5 | *1 : 258* |
| Whitechapel | 2,579 | 2,297 | 12 | — | 226 | 1 | 43 | 1·7 | *1 : 192* |
| Woolwich | 3,299 | 2,936 | 5 | — | 285 | 21 | 52 | 2·2 | *1 : 588* |
| | 133,319 | 107,494 | 421 | — | 13,390 | 1,517 | 10,497 | 9·0 | *1 : 256* |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| — | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed) per cent. of births. |
| **BEDFORD.** | | | | | | | | |
| Ampthill | 475 | 407 | — | — | 47 | 2 | 19 | 4·4 |
| Bedford | 1,345 | 1,076 | 1 | — | 137 | 30 | 101 | 9·7 |
| Biggleswade | 793 | 691 | — | — | 76 | 7 | 19 | 3·3 |
| Leighton Buzzard | 551 | 489 | 2 | — | 39 | 6 | 15 | 3·8 |
| Luton | 1,481 | 754 | 1 | — | 229 | 79 | 418 | 33·6 |
| Woburn | 249 | 215 | — | — | 21 | 4 | 9 | 5·2 |
| **BERKS.** | | | | | | | | |
| Abingdon | 611 | 561 | — | — | 45 | — | 5 | 0·8 |
| Bradfield | 589 | 521 | 1 | — | 55 | 9 | 3 | 2·0 |
| Cookham | 533 | 464 | — | — | 44 | 15 | 10 | 4·7 |
| Easthampstead | 371 | 343 | — | — | 21 | — | 7 | 1·9 |
| Faringdon | 415 | 351 | 1 | — | 38 | 6 | 19 | 6·0 |
| Hungerford | 504 | 438 | — | — | 56 | 9 | 1 | 2·0 |
| Newbury | 615 | 494 | 4 | — | 64 | 20 | 33 | 8·5 |
| Reading | 1,622 | 1,314 | 5 | — | 145 | 110 | 48 | 9·7 |
| Wallingford | 374 | 321 | 1 | — | 38 | 7 | 7 | 3·7 |
| Wantage | 494 | 440 | — | — | 41 | 8 | 5 | 2·6 |
| Windsor | 982 | 844 | 4 | — | 59 | 8 | 67 | 7·6 |
| Wokingham | 590 | 535 | — | — | 31 | 2 | 22 | 4·1 |
| **BUCKS.** | | | | | | | | |
| Amersham | 549 | 493 | — | — | 42 | 4 | 10 | 2·6 |
| Aylesbury | 802 | 682 | — | — | 88 | 11 | 21 | 4·0 |
| Buckingham | 346 | 289 | — | — | 30 | 1 | 26 | 7·8 |
| Eton | 806 | 725 | 1 | — | 56 | 9 | 15 | 3·0 |
| Newport Pagnell | 768 | 661 | 2 | — | 76 | 5 | 24 | 3·8 |
| Winslow | 213 | 194 | — | — | 17 | — | 2 | 0·9 |
| Wycombe | 1,347 | 1,162 | 1 | — | 140 | 13 | 31 | 3·3 |
| **CAMBRIDGE.** | | | | | | | | |
| Cambridge | 1,004 | 873 | 2 | — | 88 | 19 | 22 | 4·1 |
| Caxton and Arrington | 258 | 238 | — | — | 16 | 1 | 3 | 1·6 |
| Chesterton | 849 | 743 | — | — | 76 | 10 | 20 | 3·5 |
| Ely | 591 | 511 | 1 | — | 52 | 8 | 19 | 4·6 |
| Linton | 365 | 319 | 1 | — | 31 | 6 | 8 | 3·8 |
| Newmarket | 928 | 826 | 4 | — | 86 | 4 | 8 | 1·3 |
| North Witchford | 514 | 462 | — | — | 43 | 5 | 4 | 1·8 |
| Whittlesey | 182 | 161 | — | — | 15 | 3 | 3 | 3·3 |
| Wisbech | 1,030 | 874 | — | — | 105 | 10 | 41 | 5·0 |
| **CHESTER.** | | | | | | | | |
| Altrincham | 1,777 | 1,574 | 3 | — | 156 | 25 | 19 | 2·5 |
| Birkenhead | 4,014 | 3,518 | 9 | — | 376 | 22 | 89 | 2·7 |
| Chester | 1,388 | 1,219 | 4 | — | 131 | 15 | 19 | 2·4 |
| Congleton | 1,129 | 1,028 | 1 | 1 | 84 | 5 | 10 | 1·3 |
| Macclesfield | 1,713 | 1,506 | — | — | 164 | 21 | 22 | 2·5 |
| Nantwich | 2,122 | 1,760 | 5 | — | 215 | 33 | 109 | 6·7 |
| Northwich | 1,733 | 1,554 | 1 | — | 163 | 2 | 13 | 0·9 |
| Runcorn | 1,218 | 1,116 | 1 | — | 89 | 5 | 7 | 1·0 |
| Stockport | 4,080 | 3,404 | 10 | 1 | 437 | 37 | 191 | 5·6 |
| Tarvin | 320 | 288 | 1 | — | 24 | — | 7 | 2·2 |
| Wirral | 870 | 766 | — | — | 68 | 11 | 25 | 4·1 |

| — | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **CORNWALL.** | | | | | | | | |
| Austell, St. | 873 | 783 | — | — | 68 | 12 | 10 | 2·5 |
| Bodmin | 530 | 480 | 1 | — | 39 | 6 | 4 | 1·9 |
| Camelford | 189 | 174 | — | — | 10 | 3 | 2 | 2·6 |
| Columb, St., Major | 399 | 353 | — | — | 34 | 2 | 10 | 3·0 |
| Falmouth | 604 | 447 | 1 | — | 68 | 6 | 82 | 14·6 |
| Germans, St. | 474 | 412 | — | — | 37 | 7 | 18 | 5·3 |
| Helston | 682 | 565 | 1 | — | 88 | 10 | 18 | 4·1 |
| Launceston | 454 | 421 | — | — | 29 | 2 | 2 | 0·9 |
| Liskeard | 728 | 654 | 2 | — | 46 | 16 | 10 | 3·6 |
| Penzance | 1,429 | 1,172 | 3 | — | 187 | 10 | 57 | 4·7 |
| Redruth | 1,466 | 1,185 | 2 | — | 221 | 22 | 36 | 3·9 |
| Stratton | 194 | 170 | — | — | 17 | 3 | 4 | 3·6 |
| Truro | 884 | 709 | 1 | 1 | 99 | 29 | 45 | 8·4 |
| **CUMBERLAND.** | | | | | | | | |
| Alston-with-Garrigill | 79 | 71 | — | — | 3 | 3 | 2 | 6·3 |
| Bootle | 448 | 411 | — | — | 36 | — | 1 | 0·2 |
| Brampton | 272 | 236 | — | — | 22 | 14 | — | 5·1 |
| Carlisle | 1,655 | 1,440 | 1 | — | 165 | 30 | 19 | 3·0 |
| Cockermouth | 2,341 | 1,970 | 1 | — | 241 | 47 | 82 | 5·5 |
| Longtown | 210 | 188 | — | — | 15 | 6 | 1 | 3·3 |
| Penrith | 604 | 551 | — | — | 47 | 1 | 5 | 1·0 |
| Whitehaven | 1,917 | 1,636 | 3 | — | 183 | 28 | 67 | 5·0 |
| Wigton | 667 | 557 | — | — | 81 | 7 | 22 | 4·3 |
| **DERBY.** | | | | | | | | |
| Ashbourne | 582 | 511 | — | — | 48 | 2 | 21 | 4·0 |
| Bakewell | 798 | 699 | 1 | — | 63 | 17 | 18 | 4·4 |
| Belper | 1,978 | 1,790 | 2 | — | 159 | 3 | 24 | 1·4 |
| Chapel-en-le-Frith | 624 | 558 | 2 | — | 45 | 6 | 13 | 3·0 |
| Chesterfield | 3,708 | 3,004 | 3 | — | 360 | 75 | 266 | 9·2 |
| Derby | 2,673 | 2,209 | 4 | — | 281 | 26 | 153 | 6·7 |
| Glossop | 820 | 661 | 3 | — | 102 | 4 | 50 | 6·6 |
| Hayfield | 366 | 329 | 2 | — | 31 | — | 4 | 1·1 |
| Shardlow | 1,817 | 1,575 | 3 | — | 186 | 14 | 39 | 2·9 |
| **DEVON.** | | | | | | | | |
| Axminster | 484 | 447 | — | — | 22 | 3 | 12 | 3·1 |
| Barnstaple | 1,104 | 970 | — | — | 95 | 27 | 12 | 3·5 |
| Bideford | 578 | 528 | — | — | 39 | 8 | 3 | 1·9 |
| Crediton | 505 | 461 | — | — | 35 | 4 | 5 | 1·8 |
| East Stonehouse | 571 | 475 | 1 | — | 67 | 5 | 23 | 4·9 |
| Exeter | 1,041 | 866 | 2 | — | 103 | 29 | 41 | 6·7 |
| Holsworthy | 288 | 267 | — | — | 16 | 3 | 2 | 1·7 |
| Honiton | 557 | 497 | 3 | — | 30 | 9 | 18 | 4·8 |
| Kingsbridge | 474 | 429 | — | — | 38 | 6 | 1 | 1·5 |
| Newton Abbot | 1,911 | 1,737 | 4 | — | 140 | 6 | 24 | 1·6 |
| Okehampton | 467 | 424 | — | — | 25 | 7 | 11 | 3·9 |
| Plymouth | 2,432 | 1,907 | 5 | — | 325 | 36 | 159 | 8·0 |
| Plympton St. Mary | 634 | 536 | — | — | 56 | 12 | 30 | 6·6 |
| Southmolton | 454 | 411 | — | — | 26 | 9 | 8 | 3·7 |
| Stoke Damerel | 1,599 | 1,302 | 8 | — | 151 | 42 | 96 | 8·6 |
| Tavistock | 788 | 711 | — | — | 70 | 4 | 3 | 0·9 |
| Thomas, St. | 1,425 | 1,237 | 3 | — | 99 | 47 | 39 | 6·0 |
| Tiverton | 810 | 721 | 1 | — | 67 | 4 | 17 | 2·6 |
| Torrington | 399 | 351 | — | — | 33 | 7 | 8 | 3·8 |
| Totnes | 1,100 | 986 | 2 | — | 84 | 8 | 20 | 2·5 |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

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|---|---|---|---|---|---|---|---|---|
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| **DORSET.** | | | | | | | | |
| Beaminster | 326 | 295 | — | — | 28 | — | 3 | 0·9 |
| Blandford | 354 | 301 | — | — | 22 | 9 | 22 | 8·8 |
| Bridport | 371 | 333 | 1 | — | 25 | 3 | 9 | 3·2 |
| Cerne | 190 | 180 | — | — | 7 | 2 | 1 | 1·6 |
| Dorchester | 537 | 487 | — | — | 34 | 8 | 8 | 3·0 |
| Poole | 756 | 664 | 1 | — | 55 | 11 | 25 | 4·8 |
| Shaftesbury | 338 | 302 | — | — | 21 | 8 | 7 | 4·4 |
| Sherborne | 356 | 324 | — | — | 24 | 1 | 7 | 2·2 |
| Sturminster | 270 | 238 | — | — | 22 | 5 | 5 | 3·7 |
| Wareham and Purbeck | 504 | 460 | — | — | 28 | 3 | 13 | 3·2 |
| Weymouth | 747 | 609 | 1 | — | 69 | 8 | 60 | 9·1 |
| Wimborne and Cranborne | 542 | 475 | 1 | — | 39 | 12 | 15 | 5·0 |
| **DURHAM.** | | | | | | | | |
| Auckland | 3,060 | 2,552 | 3 | — | 344 | 28 | 133 | 5·3 |
| Chester-le-Street | 1,859 | 1,561 | 1 | — | 212 | 9 | 76 | 4·6 |
| Darlington | 1,517 | 1,299 | 1 | — | 135 | 8 | 74 | 5·4 |
| Durham | 2,331 | 1,981 | 2 | — | 255 | 15 | 78 | 4·0 |
| Easington | 1,844 | 1,580 | 1 | — | 217 | 12 | 34 | 2·5 |
| Gateshead | 4,642 | 3,810 | 5 | — | 585 | 50 | 192 | 5·2 |
| Hartlepool | 2,085 | 1,759 | 1 | — | 227 | 36 | 62 | 4·7 |
| Houghton-le-Spring | 1,549 | 1,327 | 4 | — | 170 | 9 | 39 | 3·1 |
| Lanchester | 2,100 | 1,787 | 1 | — | 224 | 10 | 78 | 4·2 |
| Sedgefield | 660 | 561 | — | — | 75 | 6 | 18 | 3·6 |
| South Shields | 4,925 | 3,614 | 5 | — | 621 | 181 | 504 | 13·9 |
| Stockton | 1,810 | 1,507 | 2 | — | 136 | 2 | 163 | 9·1 |
| Sunderland | 5,475 | 4,851 | 9 | — | 443 | 15 | 157 | 3·1 |
| Teesdale | 623 | 539 | 1 | — | 56 | 11 | 16 | 4·3 |
| Weardale | 472 | 408 | — | — | 53 | 7 | 4 | 2·3 |
| **ESSEX** | | | | | | | | |
| Billericay | 561 | 463 | — | — | 52 | 9 | 37 | 8·2 |
| Braintree | 800 | 722 | — | — | 51 | 12 | 15 | 3·4 |
| Chelmsford | 936 | 833 | — | — | 78 | 7 | 18 | 2·7 |
| Colchester | 939 | 758 | 7 | — | 89 | 31 | 54 | 9·1 |
| Dunmow | 445 | 395 | — | — | 32 | 11 | 7 | 4·0 |
| Epping | 710 | 635 | 2 | — | 48 | 8 | 17 | 3·5 |
| Halstead | 454 | 397 | 1 | — | 35 | 10 | 11 | 4·6 |
| Lexden and Winstree | 631 | 567 | — | — | 44 | 6 | 14 | 3·2 |
| Maldon | 666 | 593 | — | — | 54 | 5 | 14 | 2·9 |
| Ongar | 311 | 280 | — | — | 24 | 1 | 6 | 2·3 |
| Orsett | 946 | 768 | 2 | — | 82 | 7 | 87 | 9·9 |
| Rochford | 836 | 736 | — | — | 76 | 7 | 17 | 2·9 |
| Romford | 1,596 | 1,298 | 5 | — | 160 | 27 | 106 | 8·3 |
| Saffron Walden | 482 | 430 | 1 | — | 34 | 5 | 12 | 3·5 |
| Tendring | 1,126 | 1,006 | 2 | — | 93 | 6 | 19 | 2·2 |
| West Ham | 11,364 | 9,119 | 33 | — | 1,097 | 214 | 901 | 9·8 |
| **GLOUCESTER.** | | | | | | | | |
| Barton Regis | 5,544 | 4,827 | 32 | — | 465 | 47 | 173 | 4·0 |
| Bristol | 1,690 | 1,443 | 6 | — | 168 | 7 | 66 | 4·3 |
| Cheltenham | 1,324 | 957 | — | — | 168 | 33 | 166 | 15·0 |
| Chipping Sodbury | 510 | 446 | 1 | — | 38 | 4 | 21 | 4·9 |
| Cirencester | 571 | 490 | — | — | 50 | 4 | 27 | 5·4 |
| Dursley | 338 | 303 | — | — | 13 | 12 | 10 | 6·5 |
| Gloucester | 1,468 | 472 | — | — | 132 | — | 864 | 58·8 |
| Newent | 318 | 287 | — | — | 19 | 8 | 4 | 3·8 |
| Northleach | 249 | 223 | — | — | 17 | 2 | 7 | 3·6 |

| | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **GLOUCESTER—*cont.*** | | | | | | | | |
| Stow-on-the-Wold | 276 | 239 | 2 | — | 27 | 2 | 6 | 2·9 |
| Stroud | 1,184 | 1,054 | 1 | — | 86 | 11 | 32 | 3·6 |
| Tetbury | 142 | 135 | — | — | 6 | 1 | — | 0·7 |
| Tewkesbury | 391 | 332 | — | — | 41 | 5 | 15 | 4·6 |
| Thornbury | 489 | 435 | — | — | 32 | 5 | 17 | 4·5 |
| Westbury-on-Severn | 874 | 708 | — | — | 73 | 20 | 73 | 10·6 |
| Wheatenhurst | 177 | 147 | — | — | 15 | 9 | 6 | 8·5 |
| Winchcomb | 259 | 239 | — | — | 13 | — | 7 | 2·7 |
| **HEREFORD.** | | | | | | | | |
| Bromyard | 279 | 240 | — | — | 21 | 12 | 6 | 6·5 |
| Dore | 178 | 141 | — | — | 22 | 6 | 9 | 8·4 |
| Hereford | 946 | 849 | 1 | — | 72 | 9 | 15 | 2·5 |
| Kington | 329 | 296 | — | — | 21 | 4 | 8 | 3·6 |
| Ledbury | 339 | 296 | — | — | 28 | 5 | 10 | 4·4 |
| Leominster | 386 | 343 | — | — | 30 | 5 | 8 | 3·4 |
| Ross | 455 | 404 | 3 | — | 39 | 3 | 6 | 2·0 |
| Weobley | 218 | 194 | 2 | — | 13 | 1 | 8 | 4·1 |
| **HERTS.** | | | | | | | | |
| Albans, St. | 784 | 664 | 3 | — | 70 | — | 47 | 6·0 |
| Barnet | 1,212 | 966 | 1 | — | 119 | 52 | 74 | 10·4 |
| Berkhampstead | 455 | 399 | — | — | 45 | 3 | 8 | 2·4 |
| Bishop's Stortford | 630 | 568 | — | — | 43 | 7 | 12 | 3·0 |
| Buntingford | 151 | 139 | — | — | 9 | 1 | 2 | 2·0 |
| Hatfield | 204 | 172 | 1 | — | 21 | — | 10 | 4·9 |
| Hemel Hempstead | 432 | 369 | 2 | — | 49 | 4 | 8 | 2·8 |
| Hertford | 466 | 423 | — | — | 34 | 3 | 6 | 1·9 |
| Hitchin | 842 | 727 | 2 | — | 89 | 1 | 23 | 2·9 |
| Royston | 493 | 448 | — | — | 38 | 1 | 6 | 1·4 |
| Ware | 548 | 489 | 2 | — | 38 | 2 | 17 | 3·4 |
| Watford | 965 | 842 | 3 | — | 66 | 1 | 53 | 5·6 |
| Welwyn | 56 | 52 | — | — | 2 | — | 2 | 3·6 |
| **HUNTINGDON.** | | | | | | | | |
| Huntingdon | 581 | 524 | 2 | — | 40 | 7 | 8 | 2·6 |
| Ives, St. | 444 | 407 | — | — | 21 | 5 | 11 | 3·6 |
| Neots, St. | 437 | 405 | — | — | 24 | — | 8 | 1·8 |
| **KENT (Extra-Metropolitan).** | | | | | | | | |
| Ashford, East | 428 | 385 | — | — | 31 | 3 | 9 | 2·8 |
| Ashford, West | 543 | 483 | — | — | 29 | 8 | 23 | 5·7 |
| Blean | 569 | 508 | 1 | — | 41 | 6 | 13 | 3·3 |
| Bridge | 333 | 301 | 1 | — | 22 | — | 9 | 2·7 |
| Bromley | 1,850 | 1,556 | 6 | — | 243 | 19 | 26 | 2·4 |
| Canterbury | 527 | 464 | 2 | — | 50 | 2 | 9 | 2·1 |
| Cranbrook | 368 | 327 | 1 | — | 31 | — | 9 | 2·4 |
| Dartford | 1,899 | 1,652 | 4 | — | 135 | 20 | 88 | 5·7 |
| Dover | 1,124 | 797 | 2 | — | 120 | 19 | 186 | 18·2 |
| Eastry | 797 | 720 | — | — | 61 | 6 | 10 | 2·0 |
| Elham | 1,033 | 875 | 4 | — | 75 | 10 | 69 | 7·6 |
| Faversham | 835 | 764 | 1 | — | 61 | 3 | 6 | 1·1 |
| Gravesend and Milton | 736 | 596 | 1 | — | 61 | 2 | 76 | 10·6 |
| Hollingbourn | 411 | 377 | — | — | 24 | 1 | 9 | 2·4 |
| Hoo | 128 | 118 | — | — | 7 | — | 3 | 2·3 |
| Maidstone | 1,447 | 1,184 | — | — | 186 | 1 | 76 | 5·3 |

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| **KENT (Extra-Metropolitan)—*cont.*** | | | | | | | | |
| Malling | 909 | 807 | 1 | — | 54 | 17 | 30 | 5·2 |
| Medway | 2,321 | 1,960 | 4 | — | 231 | 16 | 110 | 5·4 |
| Milton | 910 | 808 | 4 | — | 75 | 10 | 13 | 2·5 |
| Romney Marsh | 200 | 186 | — | — | 14 | — | — | 0·0 |
| Sevenoaks | 905 | 782 | — | — | 60 | 11 | 52 | 7·0 |
| Sheppey | 561 | 489 | 2 | — | 50 | 11 | 9 | 3·6 |
| Strood | 1,157 | 1,009 | 1 | — | 107 | 9 | 31 | 3·5 |
| Tenterden | 301 | 279 | — | — | 20 | — | 2 | 0·7 |
| Thanet, Isle of | 1,457 | 1,304 | 5 | — | 105 | 19 | 24 | 3·0 |
| Tonbridge | 1,545 | 1,354 | 2 | — | 105 | 18 | 66 | 5·4 |
| **LANCASTER.** | | | | | | | | |
| Ashton-under-Lyne | 5,229 | 4,187 | 12 | 1 | 606 | 48 | 375 | 8·1 |
| Barrow-in-Furness | 1,571 | 1,399 | — | — | 123 | 13 | 36 | 3·1 |
| Barton-upon-Irwell | 2,593 | 2,150 | 8 | — | 217 | 100 | 118 | 8·4 |
| Blackburn | 6,764 | 5,822 | 4 | — | 772 | 46 | 120 | 2·5 |
| Bolton | 6,863 | 6,204 | 10 | — | 588 | 10 | 51 | 0·9 |
| Burnley | 5,275 | 3,845 | 5 | — | 688 | 31 | 706 | 14·0 |
| Bury | 4,272 | 3,739 | 17 | — | 432 | 26 | 58 | 2·0 |
| Chorley | 1,701 | 1,437 | 3 | — | 175 | 1 | 85 | 5·1 |
| Chorlton | 9,126 | 7,351 | 14 | — | 1,002 | 179 | 580 | 8·3 |
| Clitheroe | 615 | 537 | 1 | — | 43 | 15 | 19 | 5·5 |
| Fylde, The | 1,401 | 1,234 | 4 | — | 122 | 14 | 27 | 2·9 |
| Garstang | 323 | 274 | — | — | 26 | — | 23 | 7·1 |
| Haslingden | 3,048 | 2,702 | 9 | — | 275 | 9 | 53 | 2·0 |
| Lancaster | 1,400 | 1,221 | 4 | — | 137 | 14 | 24 | 2·7 |
| Leigh | 2,480 | 2,134 | — | — | 250 | 9 | 87 | 3·9 |
| Liverpool | 5,583 | 4,545 | 17 | — | 700 | 10 | 311 | 5·7 |
| Lunesdale | 198 | 179 | — | — | 13 | 1 | 5 | 3·0 |
| Manchester | 5,292 | 4,448 | 6 | — | 653 | 52 | 133 | 3·5 |
| Oldham | 6,361 | 2,636 | 19 | — | 899 | 176 | 2,631 | 44·1 |
| Ormskirk | 2,638 | 2,284 | 8 | — | 270 | 20 | 56 | 2·9 |
| Prescot | 4,945 | 4,094 | 3 | — | 595 | 74 | 179 | 5·1 |
| Preston | 4,893 | 3,806 | 6 | — | 682 | 37 | 362 | 8·2 |
| Prestwich | 4,885 | 4,046 | 6 | — | 434 | 46 | 353 | 8·2 |
| Rochdale | 3,198 | 2,789 | 4 | — | 295 | 31 | 79 | 3·4 |
| Salford | 7,173 | 5,559 | 17 | — | 915 | 205 | 477 | 9·5 |
| Todmorden | 978 | 828 | 2 | — | 110 | — | 38 | 3·9 |
| Toxteth Park | 4,401 | 3,460 | 22 | — | 491 | 144 | 284 | 9·7 |
| Ulverston | 1,491 | 1,328 | — | — | 119 | 25 | 19 | 3·0 |
| Warrington | 2,936 | 2,482 | 3 | — | 331 | 24 | 96 | 4·1 |
| West Derby | 14,775 | 12,477 | 19 | — | 1,441 | 181 | 657 | 5·7 |
| Wigan | 6,338 | 5,458 | 5 | — | 675 | 63 | 137 | 3·2 |
| **LEICESTER.** | | | | | | | | |
| Ashby-de-la-Zouch | 1,213 | 1,020 | 1 | — | 130 | 8 | 54 | 5·1 |
| Barrow-on-Soar | 1,048 | 668 | 1 | — | 151 | 27 | 201 | 21·8 |
| Billesdon | 362 | 232 | — | — | 45 | — | 85 | 23·5 |
| Blaby | 1,076 | 782 | 2 | — | 149 | 10 | 133 | 13·3 |
| Hinckley | 685 | 588 | — | — | 76 | 2 | 19 | 3·1 |
| Leicester | 4,693 | 343 | 3 | — | 961 | — | 3,386 | 72·2 |
| Loughborough | 984 | 807 | — | — | 107 | 28 | 42 | 7·1 |
| Lutterworth | 303 | 279 | — | — | 18 | 2 | 4 | 2·0 |
| Market Bosworth | 511 | 450 | 1 | — | 33 | 10 | 17 | 5·3 |
| Market Harborough | 466 | 409 | 1 | — | 36 | 1 | 19 | 4·3 |
| Melton Mowbray | 613 | 523 | — | — | 60 | 2 | 28 | 4·9 |

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|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **LINCOLN.** | | | | | | | | |
| Boston | 1,098 | 937 | — | — | 110 | 13 | 38 | 4·6 |
| Bourn | 571 | 496 | 1 | — | 50 | 15 | 9 | 4·2 |
| Caistor | 2,538 | 2,006 | 5 | 4 | 415 | 39 | 69 | 4·3 |
| Gainsborough | 1,036 | 890 | — | — | 116 | 3 | 27 | 2·9 |
| Glanford Brigg | 1,302 | 1,149 | 1 | — | 113 | 9 | 30 | 3·0 |
| Grantham | 1,017 | 889 | — | — | 101 | 6 | 21 | 2·7 |
| Holbeach | 543 | 447 | — | — | 68 | 3 | 25 | 5·2 |
| Horncastle | 581 | 522 | — | — | 43 | 2 | 14 | 2·8 |
| Lincoln | 1,965 | 1,584 | 5 | — | 248 | 50 | 78 | 6·5 |
| Louth | 893 | 770 | 3 | — | 79 | 14 | 27 | 4·6 |
| Sleaford | 700 | 617 | — | — | 66 | 4 | 13 | 2·4 |
| Spalding | 651 | 567 | — | — | 50 | 8 | 26 | 5·2 |
| Spilsby | 750 | 686 | 3 | — | 37 | 9 | 15 | 3·2 |
| Stamford | 465 | 388 | — | — | 50 | 3 | 24 | 5·8 |
| **MIDDLESEX (Extra-Metropolitan).** | | | | | | | | |
| Brentford | 3,814 | 3,143 | 10 | — | 388 | 23 | 250 | 7·2 |
| Edmonton | 6,736 | 5,543 | 19 | — | 537 | 80 | 557 | 9·5 |
| Hendon | 2,661 | 2,006 | 6 | — | 280 | 29 | 340 | 13·9 |
| Staines | 745 | 648 | — | — | 54 | 13 | 30 | 5·8 |
| Uxbridge | 872 | 785 | 2 | — | 62 | 6 | 17 | 2·7 |
| **MONMOUTH.** | | | | | | | | |
| Abergavenny | 785 | 685 | — | — | 68 | 14 | 18 | 4·1 |
| Bedwellty | 2,208 | 1,824 | — | — | 247 | 47 | 90 | 6·2 |
| Chepstow | 594 | 526 | — | — | 42 | 13 | 13 | 4·4 |
| Monmouth | 831 | 743 | — | — | 61 | 9 | 18 | 3·2 |
| Newport | 3,173 | 2,753 | 3 | — | 293 | 24 | 100 | 3·9 |
| Pontypool | 1,232 | 1,094 | — | — | 93 | 12 | 33 | 3·7 |
| **NORFOLK.** | | | | | | | | |
| Aylsham | 535 | 470 | 1 | — | 52 | 3 | 9 | 2·2 |
| Blofield | 363 | 317 | 1 | — | 34 | 4 | 7 | 3·0 |
| Depwade | 665 | 588 | — | — | 47 | 16 | 14 | 4·5 |
| Docking | 457 | 407 | — | — | 38 | 4 | 8 | 2·6 |
| Downham | 518 | 444 | — | — | 65 | — | 9 | 1·7 |
| Erpingham | 575 | 483 | 1 | — | 52 | 18 | 21 | 6·8 |
| Faith, St. | 344 | 304 | — | — | 27 | 3 | 10 | 3·8 |
| Fleggs, East and West | 338 | 285 | — | — | 43 | 5 | 5 | 3·0 |
| Forehoe | 369 | 320 | — | — | 36 | 2 | 11 | 3·5 |
| Freebridge Lynn | 419 | 363 | 1 | — | 39 | 6 | 10 | 3·8 |
| Guiltcross | 321 | 288 | — | — | 24 | 2 | 7 | 2·8 |
| Henstead | 315 | 264 | 2 | — | 28 | 14 | 7 | 6·7 |
| King's Lynn | 592 | 495 | — | — | 62 | 20 | 15 | 5·9 |
| Loddon and Clavering | 430 | 376 | 1 | — | 32 | 4 | 17 | 4·9 |
| Mitford and Launditch | 773 | 682 | 2 | — | 58 | 22 | 9 | 4·0 |
| Norwich | 3,149 | 2,607 | 7 | — | 317 | 25 | 193 | 6·9 |
| Smallburgh | 539 | 460 | — | — | 55 | 4 | 20 | 4·5 |
| Swaffham | 369 | 308 | — | — | 36 | 7 | 18 | 6·8 |
| Thetford | 555 | 490 | 1 | — | 55 | 1 | 8 | 1·6 |
| Walsingham | 570 | 487 | — | — | 58 | 1 | 24 | 4·4 |
| Wayland | 287 | 259 | 1 | — | 23 | 2 | 2 | 1·4 |
| Yarmouth, Great | 1,190 | 939 | 3 | — | 137 | 39 | 72 | 9·3 |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **NORTHAMPTON.** | | | | | | | | |
| Brackley | 327 | 280 | 5 | — | 20 | 6 | 16 | 6·7 |
| Brixworth | 339 | 284 | 1 | — | 43 | 2 | 9 | 3·2 |
| Daventry | 515 | 470 | 1 | — | 25 | 1 | 18 | 3·7 |
| Hardingstone | 333 | 298 | — | — | 24 | 2 | 9 | 3·3 |
| Kettering | 1,079 | 654 | 1 | — | 132 | 7 | 285 | 27·1 |
| Northampton | 2,403 | 1,438 | 1 | — | 346 | 26 | 592 | 25·7 |
| Oundle | 340 | 316 | — | — | 18 | 1 | 5 | 1·8 |
| Peterborough | 1,327 | 1,185 | 1 | — | 97 | 5 | 39 | 3·3 |
| Potterspury | 351 | 290 | — | — | 43 | 11 | 7 | 5·1 |
| Thrapston | 431 | 351 | — | — | 39 | 6 | 35 | 9·5 |
| Towcester | 371 | 333 | — | — | 24 | 8 | 6 | 3·8 |
| Wellingborough | 1,360 | 1,022 | 1 | — | 157 | 27 | 153 | 13·2 |
| **NORTHUMBERLAND.** | | | | | | | | |
| Alnwick | 697 | 587 | — | — | 49 | 19 | 42 | 8·8 |
| Belford | 158 | 147 | — | — | 11 | — | — | 0·0 |
| Bellingham | 142 | 130 | — | — | 8 | — | 4 | 2·8 |
| Berwick-upon-Tweed | 577 | 515 | — | — | 43 | 13 | 6 | 3·3 |
| Castle Ward | 744 | 626 | 1 | — | 83 | 2 | 32 | 4·6 |
| Glendale | 264 | 242 | — | — | 16 | 4 | 2 | 2·3 |
| Haltwhistle | 208 | 183 | — | — | 17 | 5 | 3 | 3·8 |
| Hexham | 987 | 866 | — | — | 68 | 8 | 45 | 5·4 |
| Morpeth | 1,402 | 1,132 | — | — | 233 | 7 | 30 | 2·6 |
| Newcastle-on-Tyne | 6,521 | 5,597 | 11 | — | 733 | 84 | 96 | 2·8 |
| Rothbury | 157 | 147 | — | — | 6 | — | 4 | 2·5 |
| Tynemouth | 4,330 | 3,598 | 7 | — | 463 | 118 | 144 | 6·1 |
| **NOTTINGHAM.** | | | | | | | | |
| Basford | 5,502 | 4,698 | 7 | — | 592 | 26 | 179 | 3·7 |
| Bingham | 386 | 358 | — | — | 17 | 4 | 7 | 2·8 |
| East Retford | 680 | 622 | 2 | — | 44 | 2 | 10 | 1·8 |
| Mansfield | 1,929 | 1,609 | 4 | — | 225 | 7 | 84 | 4·7 |
| Newark | 872 | 772 | 1 | — | 78 | 5 | 16 | 2·4 |
| Nottingham | 6,102 | 4,412 | 11 | — | 759 | 87 | 833 | 15·1 |
| Southwell | 514 | 456 | 1 | — | 38 | 4 | 15 | 3·7 |
| Worksop | 1,073 | 947 | 2 | — | 109 | 6 | 9 | 1·4 |
| **OXFORD.** | | | | | | | | |
| Banbury | 906 | 584 | — | — | 93 | 9 | 220 | 25·3 |
| Bicester | 380 | 346 | — | — | 21 | 7 | 6 | 3·4 |
| Chipping Norton | 550 | 493 | 1 | — | 31 | 18 | 7 | 4·5 |
| Headington | 968 | 873 | — | — | 77 | 4 | 14 | 1·9 |
| Henley | 626 | 559 | — | — | 32 | 16 | 19 | 5·6 |
| Oxford | 641 | 542 | 3 | — | 76 | 3 | 17 | 3·1 |
| Thame | 392 | 360 | — | — | 20 | 3 | 9 | 3·1 |
| Witney | 632 | 559 | 2 | — | 55 | 8 | 8 | 2·5 |
| Woodstock | 406 | 352 | 3 | — | 31 | 8 | 12 | 5·0 |
| **RUTLAND.** | | | | | | | | |
| Oakham | 305 | 274 | — | — | 23 | 2 | 6 | 2·6 |
| Uppingham | 309 | 265 | 2 | — | 32 | 3 | 7 | 3·2 |

| — | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **SALOP.** | | | | | | | | |
| Atcham | 1,284 | 1,081 | 2 | — | 118 | 22 | 61 | 6·5 |
| Bridgnorth | 388 | 333 | — | — | 35 | 5 | 15 | 5·2 |
| Church Stretton | 123 | 111 | — | — | 11 | — | 1 | 0·8 |
| Cleobury Mortimer | 259 | 226 | — | — | 20 | 8 | 5 | 5·0 |
| Clun | 261 | 233 | — | — | 18 | 5 | 5 | 3·8 |
| Drayton | 407 | 378 | — | — | 26 | 1 | 2 | 0·7 |
| Ellesmere | 320 | 297 | — | — | 18 | 1 | 4 | 1·6 |
| Ludlow | 529 | 457 | 1 | — | 47 | 6 | 18 | 4·5 |
| Madeley | 693 | 630 | 2 | — | 48 | — | 13 | 1·9 |
| Newport | 454 | 394 | — | — | 42 | 7 | 11 | 4·0 |
| Oswestry | 805 | 724 | 1 | — | 59 | 11 | 10 | 2·6 |
| Shifnal | 346 | 308 | — | — | 22 | 3 | 13 | 4·6 |
| Wellington | 776 | 686 | — | — | 70 | 8 | 12 | 2·6 |
| Wem | 289 | 264 | — | — | 18 | 4 | 3 | 2·4 |
| Whitchurch | 356 | 322 | — | — | 27 | 3 | 4 | 2·0 |
| **SOMERSET.** | | | | | | | | |
| Axbridge | 1,124 | 987 | 1 | — | 75 | 21 | 40 | 5·4 |
| Bath | 1,747 | 1,265 | 2 | — | 167 | 71 | 242 | 17·9 |
| Bedminster | 2,469 | 2,093 | 4 | — | 255 | 56 | 61 | 4·7 |
| Bridgwater | 1,006 | 856 | 1 | — | 98 | 17 | 34 | 5·1 |
| Chard | 773 | 678 | — | — | 61 | 15 | 19 | 4·4 |
| Clutton | 848 | 768 | — | — | 54 | 10 | 16 | 3·1 |
| Dulverton | 126 | 118 | — | — | 6 | — | 2 | 1·6 |
| Frome | 662 | 609 | — | — | 35 | — | 18 | 2·7 |
| Keynsham | 911 | 773 | 7 | — | 98 | 21 | 12 | 3·6 |
| Langport | 420 | 388 | — | — | 24 | 5 | 3 | 1·9 |
| Shepton Mallet | 498 | 443 | — | — | 36 | 1 | 18 | 3·8 |
| Taunton | 1,023 | 870 | 1 | — | 94 | 22 | 36 | 5·7 |
| Wellington | 553 | 485 | — | — | 43 | 11 | 14 | 4·5 |
| Wells | 652 | 580 | 1 | — | 50 | 7 | 14 | 3·2 |
| Williton | 475 | 429 | 2 | — | 34 | 8 | 2 | 2·1 |
| Wincanton | 565 | 520 | — | — | 34 | 3 | 8 | 1·9 |
| Yeovil | 746 | 653 | — | — | 61 | 14 | 18 | 4·3 |
| **SOUTHAMPTON.** | | | | | | | | |
| Alresford | 167 | 148 | — | — | 13 | 2 | 4 | 3·6 |
| Alton | 487 | 438 | — | — | 28 | 2 | 19 | 4·3 |
| Alverstoke | 796 | 722 | 1 | 1 | 65 | 1 | 6 | 0·9 |
| Andover | 422 | 364 | — | — | 25 | 15 | 18 | 7·8 |
| Basingstoke | 628 | 488 | — | — | 52 | 7 | 81 | 14·0 |
| Catherington | 71 | 61 | — | — | 6 | 1 | 3 | 5·6 |
| Christchurch | 1,223 | 980 | 3 | — | 105 | 38 | 97 | 11·0 |
| Droxford | 315 | 274 | — | — | 20 | 9 | 12 | 6·7 |
| Fareham | 541 | 493 | 1 | — | 29 | 3 | 15 | 3·3 |
| Fordingbridge | 202 | 184 | — | — | 13 | — | 5 | 2·5 |
| Hartley Wintney | 639 | 550 | 2 | — | 49 | 9 | 29 | 5·9 |
| Havant | 303 | 264 | 1 | — | 30 | 4 | 4 | 2·6 |
| Hursley | 79 | 75 | — | — | 2 | 1 | 1 | 2·5 |
| Kingsclere | 278 | 258 | — | — | 18 | 1 | 1 | 0·7 |
| Lymington | 349 | 300 | — | — | 26 | 8 | 15 | 6·6 |
| New Forest | 416 | 373 | — | — | 24 | 6 | 13 | 4·6 |
| Petersfield | 294 | 253 | 1 | — | 26 | 3 | 11 | 4·8 |
| Portsea Island | 5,068 | 4,502 | 19 | — | 438 | 19 | 90 | 2·2 |
| Ringwood | 162 | 146 | — | — | 13 | — | 3 | 1·9 |
| Romsey | 329 | 294 | — | — | 22 | 3 | 10 | 4·0 |
| Southampton | 1,674 | 1,382 | — | — | 182 | 27 | 83 | 6·6 |
| South Stoneham | 1,440 | 1,212 | — | — | 121 | 32 | 75 | 7·4 |
| Stockbridge | 184 | 163 | — | — | 13 | 3 | 5 | 4·3 |
| Whitchurch | 183 | 165 | — | — | 13 | 4 | 1 | 2·7 |
| Wight, Isle of | 1,936 | 1,658 | 1 | — | 134 | 63 | 80 | 7·4 |
| Winchester, New | 825 | 727 | — | — | 69 | 9 | 20 | 3·5 |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **STAFFORD.** | | | | | | | | |
| Burton-upon-Trent | 2,820 | 2,334 | 2 | — | 286 | 33 | 165 | 7·0 |
| Cannock | 1,314 | 1,142 | — | — | 139 | 4 | 29 | 2·5 |
| Cheadle | 760 | 643 | — | — | 91 | 6 | 20 | 3·4 |
| Leek | 1,036 | 919 | 1 | — | 85 | 11 | 20 | 3·0 |
| Lichfield | 1,233 | 1,111 | — | — | 94 | 7 | 21 | 2·3 |
| Newcastle-under-Lyme | 1,296 | 1,142 | 1 | — | 118 | 4 | 31 | 2·7 |
| Seisdon | 472 | 414 | — | — | 40 | 2 | 16 | 3·8 |
| Stafford | 972 | 850 | — | — | 76 | 11 | 35 | 4·7 |
| Stoke-upon-Trent | 4,260 | 3,521 | — | — | 499 | 50 | 190 | 5·6 |
| Stone | 937 | 824 | 1 | — | 81 | 10 | 21 | 3·3 |
| Tamworth | 646 | 562 | — | — | 47 | 10 | 27 | 5·7 |
| Uttoxeter | 404 | 367 | — | — | 26 | 4 | 7 | 2·7 |
| Walsall | 3,415 | 2,550 | 14 | — | 418 | 37 | 396 | 12·7 |
| West Bromwich | 4,786 | 4,133 | 12 | — | 513 | 35 | 93 | 2·7 |
| Wolstanton and Burslem | 2,972 | 2,584 | 1 | — | 364 | 5 | 18 | 0·8 |
| Wolverhampton | 4,669 | 3,871 | 10 | — | 577 | 39 | 172 | 4·5 |
| **SUFFOLK.** | | | | | | | | |
| Blything | 804 | 697 | 1 | — | 63 | 9 | 34 | 5·3 |
| Bosmere and Claydon | 496 | 408 | 2 | — | 47 | 11 | 28 | 7·9 |
| Bury St. Edmunds | 470 | 410 | — | — | 44 | 7 | 9 | 3·4 |
| Cosford | 486 | 448 | 1 | — | 24 | 8 | 5 | 2·7 |
| Hartismere | 430 | 369 | 2 | — | 39 | 4 | 16 | 4·7 |
| Hoxne | 356 | 325 | — | — | 24 | 2 | 5 | 2·0 |
| Ipswich | 1,688 | 1,248 | 4 | — | 164 | 56 | 216 | 16·1 |
| Mildenhall | 260 | 230 | — | — | 19 | 1 | 10 | 4·2 |
| Mutford and Lothingland | 1,598 | 1,441 | 5 | — | 114 | 18 | 20 | 2·4 |
| Plomesgate | 568 | 500 | — | — | 38 | 4 | 26 | 5·3 |
| Risbridge | 583 | 526 | — | — | 41 | 7 | 9 | 2·7 |
| Samford | 359 | 329 | — | — | 23 | 2 | 5 | 1·9 |
| Stow | 588 | 528 | 2 | — | 43 | 5 | 10 | 2·6 |
| Sudbury | 899 | 800 | — | — | 75 | 11 | 13 | 2·7 |
| Thingoe | 483 | 432 | — | — | 40 | 5 | 6 | 2·3 |
| Wangford | 426 | 384 | — | — | 36 | 2 | 4 | 1·4 |
| Woodbridge | 624 | 557 | 1 | — | 42 | 9 | 15 | 3·8 |
| **SURREY (Extra-Metropolitan).** | | | | | | | | |
| Chertsey | 825 | 685 | 1 | — | 61 | 33 | 45 | 9·5 |
| Croydon | 3,785 | 3,093 | 9 | — | 307 | 39 | 337 | 9·9 |
| Dorking | 454 | 404 | — | — | 27 | 2 | 21 | 5·1 |
| Epsom | 1,142 | 982 | 2 | — | 73 | 10 | 75 | 7·4 |
| Farnham | 1,398 | 1,210 | 2 | — | 114 | 11 | 61 | 5·2 |
| Godstone | 463 | 398 | — | — | 34 | 8 | 23 | 6·7 |
| Guildford | 1,450 | 1,320 | — | — | 99 | 10 | 21 | 2·1 |
| Hambledon | 486 | 453 | — | — | 24 | — | 9 | 1·9 |
| Kingston | 2,784 | 2,440 | 6 | — | 250 | 39 | 49 | 3·2 |
| Reigate | 861 | 786 | 1 | — | 49 | 8 | 17 | 2·9 |
| Richmond | 1,079 | 995 | 3 | — | 61 | — | 20 | 1·9 |
| **SUSSEX.** | | | | | | | | |
| Battle | 493 | 411 | 2 | — | 44 | 6 | 30 | 7·3 |
| Brighton | 2,722 | 2,335 | 6 | — | 258 | 24 | 99 | 4·5 |
| Chailey | 268 | 241 | — | — | 13 | 5 | 9 | 5·2 |
| Chichester | 215 | 180 | — | — | 26 | 5 | 4 | 4·2 |
| Cuckfield | 626 | 537 | 1 | — | 48 | 21 | 19 | 6·4 |
| Eastbourne | 1,018 | 579 | 2 | — | 109 | 20 | 308 | 32·2 |
| East Grinstead | 553 | 478 | 1 | — | 46 | 14 | 14 | 5·1 |
| East Preston | 765 | 682 | — | — | 33 | 27 | 2 | 6·5 |

| — | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| SUSSEX—*cont.* | | | | | | | | |
| Hailsham | 440 | 387 | — | — | 33 | 3 | 17 | 4·5 |
| Hastings | 1,397 | 1,142 | 1 | — | 113 | 50 | 91 | 10·1 |
| Horsham | 676 | 591 | — | — | 55 | 5 | 25 | 4·4 |
| Lewes | 299 | 246 | — | — | 20 | 3 | 30 | 11·0 |
| Midhurst | 347 | 325 | — | — | 16 | 2 | 4 | 1·7 |
| Newhaven | 246 | 193 | — | — | 30 | 5 | 18 | 9·3 |
| Petworth | 262 | 251 | — | — | 8 | 3 | — | 1·1 |
| Rye | 353 | 317 | — | — | 22 | 6 | 8 | 4·0 |
| Steyning | 1,444 | 1,294 | 3 | — | 108 | 12 | 27 | 2·7 |
| Thakeham | 246 | 227 | — | — | 14 | 5 | — | 2·0 |
| Ticehurst | 481 | 409 | — | — | 46 | 2 | 24 | 5·4 |
| Uckfield | 572 | 507 | 1 | — | 37 | 10 | 17 | 4·7 |
| Westbourne | 225 | 198 | — | — | 21 | 1 | 5 | 2·7 |
| West Firle | 63 | 57 | — | — | 4 | 2 | — | 3·2 |
| Westhampnett | 559 | 505 | 2 | — | 26 | 8 | 18 | 4·7 |
| WARWICK. | | | | | | | | |
| Alcester | 592 | 522 | — | — | 55 | 7 | 8 | 2·5 |
| Aston | 8,314 | 6,635 | 18 | — | 944 | 70 | 647 | 8·6 |
| Atherstone | 555 | 470 | — | — | 52 | 2 | 31 | 5·9 |
| Birmingham | 8,189 | 6,838 | 18 | — | 883 | 22 | 428 | 5·5 |
| Coventry | 1,472 | 1,248 | 1 | — | 162 | 43 | 18 | 4·1 |
| Foleshill | 592 | 494 | — | — | 64 | 8 | 26 | 5·7 |
| Meriden | 289 | 263 | — | — | 22 | 1 | 3 | 1·4 |
| Nuneaton | 473 | 392 | — | — | 59 | 2 | 20 | 4·6 |
| Rugby | 814 | 743 | — | — | 54 | 4 | 13 | 2·1 |
| Solihull | 693 | 608 | 3 | — | 42 | 11 | 29 | 5·8 |
| Southam | 343 | 295 | — | — | 26 | 1 | 21 | 6·4 |
| Stratford-on-Avon | 603 | 538 | — | — | 40 | 5 | 25 | 4·9 |
| Warwick | 1,387 | 1,219 | 3 | — | 113 | 11 | 41 | 3·7 |
| WESTMORLAND. | | | | | | | | |
| East Ward | 383 | 345 | — | — | 32 | 3 | 3 | 1·6 |
| Kendal | 1,234 | 1,140 | 1 | — | 82 | 9 | 2 | 0·9 |
| West Ward | 194 | 175 | — | — | 15 | — | 4 | 2·1 |
| WILTS. | | | | | | | | |
| Alderbury | 758 | 639 | — | — | 63 | 9 | 47 | 7·4 |
| Amesbury | 189 | 178 | — | — | 10 | — | 1 | 0·5 |
| Bradford | 331 | 296 | — | — | 29 | — | 6 | 1·8 |
| Calne | 221 | 188 | — | — | 18 | 11 | 4 | 6·8 |
| Chippenham | 634 | 568 | 1 | — | 37 | 17 | 11 | 4·4 |
| Cricklade and Wootton Bassett. | 368 | 329 | — | — | 31 | 3 | 5 | 2·2 |
| Devizes | 523 | 443 | — | — | 47 | 14 | 19 | 6·3 |
| Highworth and Swindon | 1,439 | 1,236 | — | — | 126 | 41 | 36 | 5·4 |
| Malmesbury | 405 | 351 | — | — | 38 | 2 | 14 | 4·0 |
| Marlborough | 243 | 211 | — | — | 21 | 5 | 6 | 4·5 |
| Melksham | 509 | 448 | — | — | 48 | 5 | 8 | 2·6 |
| Mere | 188 | 165 | — | — | 18 | 2 | 3 | 2·7 |
| Pewsey | 339 | 300 | — | — | 34 | 2 | 3 | 1·5 |
| Tisbury | 243 | 219 | — | — | 13 | 2 | 9 | 4·5 |
| Warminster | 340 | 290 | — | — | 27 | 2 | 21 | 6·8 |
| Westbury and Whorwellsdown. | 273 | 252 | — | — | 21 | — | — | 0·0 |
| Wilton | 265 | 244 | — | — | 20 | — | 1 | 0·4 |

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Digest of Vaccination Officers' Returns.

| — | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
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| **WORCESTER.** | | | | | | | | |
| Bromsgrove | 1,026 | 888 | 1 | — | 104 | 12 | 21 | 3·2 |
| Droitwich | 550 | 468 | 1 | — | 57 | 7 | 17 | 4·4 |
| Dudley | 5,272 | 4,608 | 11 | — | 528 | 35 | 90 | 2·4 |
| Evesham | 431 | 385 | — | — | 35 | 3 | 8 | 2·5 |
| Kidderminster | 1,273 | 1,122 | 2 | — | 116 | 2 | 31 | 2·6 |
| King's Norton | 3,264 | 2,884 | 2 | — | 280 | 35 | 63 | 3·0 |
| Martley | 417 | 382 | — | — | 23 | 5 | 7 | 2·9 |
| Pershore | 373 | 339 | — | — | 26 | 4 | 4 | 2·1 |
| Shipston-on-Stour | 455 | 385 | — | — | 53 | 3 | 14 | 3·7 |
| Stourbridge | 2,847 | 2,477 | 2 | — | 313 | 10 | 45 | 1·9 |
| Tenbury | 189 | 169 | — | — | 9 | 2 | 9 | 5·8 |
| Upton-on-Severn | 559 | 488 | 3 | — | 48 | 4 | 16 | 3·6 |
| Worcester | 1,377 | 1,076 | 5 | — | 201 | 22 | 73 | 6·9 |
| **YORK, East Riding.** | | | | | | | | |
| Beverley | 705 | 595 | — | — | 79 | 10 | 21 | 4·4 |
| Bridlington | 469 | 397 | 2 | — | 51 | 2 | 17 | 4·1 |
| Driffield | 609 | 515 | 3 | — | 61 | 8 | 22 | 4·9 |
| Howden | 397 | 334 | — | — | 42 | 5 | 16 | 5·3 |
| Kingston-upon-Hull | 2,558 | 1,999 | 9 | — | 291 | 8 | 251 | 10·1 |
| Patrington | 252 | 231 | — | — | 16 | — | 5 | 2·0 |
| Pocklington | 461 | 385 | 2 | — | 51 | 6 | 17 | 5·0 |
| Sculcoates | 4,311 | 3,541 | 13 | — | 456 | 30 | 271 | 7·0 |
| Skirlaugh | 254 | 218 | — | — | 28 | 4 | 4 | 3·1 |
| York | 2,414 | 2,021 | 5 | — | 260 | 26 | 102 | 5·3 |
| **YORK, North Riding.** | | | | | | | | |
| Aysgarth | 143 | 120 | — | — | 18 | 1 | 4 | 3·5 |
| Bedale | 220 | 203 | — | — | 12 | — | 5 | 2·3 |
| Easingwold | 260 | 239 | — | — | 16 | 1 | 4 | 1·9 |
| Guisborough | 1,315 | 1,148 | 3 | — | 123 | 10 | 31 | 3·1 |
| Helmsley Blackmoor | 173 | 152 | — | — | 18 | — | 3 | 1·7 |
| Kirkby Moorside | 149 | 130 | — | — | 11 | 3 | 5 | 5·4 |
| Leyburn | 208 | 193 | — | — | 12 | 1 | 2 | 1·4 |
| Malton | 649 | 527 | — | — | 78 | 7 | 37 | 6·8 |
| Middlesbrough | 4,030 | 3,490 | 4 | — | 432 | 59 | 45 | 2·6 |
| Northallerton | 332 | 315 | 1 | — | 15 | 1 | — | 0·3 |
| Pickering | 329 | 270 | 2 | — | 39 | 2 | 16 | 5·5 |
| Reeth | 114 | 101 | — | — | 7 | 3 | 3 | 5·3 |
| Richmond | 328 | 287 | — | — | 18 | 8 | 15 | 7·0 |
| Scarborough | 1,264 | 989 | 4 | — | 126 | 35 | 110 | 11·5 |
| Stokesley | 328 | 298 | — | — | 23 | 1 | 6 | 2·1 |
| Thirsk | 367 | 325 | — | — | 29 | 5 | 8 | 3·5 |
| Whitby | 807 | 736 | — | — | 51 | 9 | 11 | 2·5 |
| **YORK, West Riding.** | | | | | | | | |
| Barnsley | 3,405 | 2,817 | 6 | — | 409 | 25 | 148 | 5·1 |
| Bramley | 2,012 | 1,674 | 1 | — | 244 | 23 | 70 | 4·6 |
| Bradford | 5,852 | 4,493 | 2 | — | 743 | 10 | 604 | 10·5 |
| Bierley, North | 3,758 | 3,187 | 9 | — | 345 | 40 | 177 | 5·8 |
| Dewsbury | 4,987 | 2,812 | 6 | — | 695 | 53 | 1,421 | 29·6 |
| Doncaster | 1,965 | 1,681 | 5 | — | 198 | 52 | 29 | 4·1 |
| Ecclesall Bierlow | 3,833 | 3,330 | 5 | 3 | 421 | 10 | 64 | 1·9 |
| Goole | 812 | 727 | — | — | 68 | 1 | 16 | 2·1 |
| Halifax | 5,061 | 3,030 | 13 | — | 593 | 125 | 1,300 | 28·2 |

| | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed) per cent. of births. |
| **YORK, West Riding—*cont.*** | | | | | | | | |
| Hemsworth | 466 | 407 | — | — | 40 | 3 | 16 | 4·1 |
| Holbeck | 807 | 676 | 1 | — | 105 | 13 | 12 | 3·1 |
| Huddersfield | 4,681 | 4,179 | 4 | — | 441 | 15 | 42 | 1·2 |
| Hunslet | 2,404 | 2,036 | 6 | — | 285 | 17 | 60 | 3·2 |
| Keighley | 1,913 | 220 | — | — | 251 | — | 1,442 | 75·4 |
| Knaresborough | 630 | 520 | 5 | — | 66 | 2 | 37 | 6·2 |
| Leeds | 6,866 | 5,949 | 8 | — | 624 | 33 | 252 | 4·2 |
| Ouseburn, Great | 344 | 298 | — | — | 33 | 4 | 9 | 3·8 |
| Pateley Bridge | 186 | 164 | 1 | — | 20 | — | 1 | 0·5 |
| Penistone | 537 | 465 | 1 | — | 52 | 7 | 12 | 3·5 |
| Pontefract | 2,070 | 1,776 | 1 | — | 204 | 14 | 75 | 4·3 |
| Ripon | 483 | 363 | — | — | 52 | 6 | 62 | 14·1 |
| Rotherham | 3,017 | 2,610 | 1 | 2 | 321 | 8 | 75 | 2·8 |
| Saddleworth | 595 | 521 | 2 | — | 53 | 3 | 16 | 3·2 |
| Sedbergh | 97 | 87 | — | — | 10 | — | — | 0·0 |
| Selby | 470 | 407 | 3 | — | 46 | 4 | 10 | 3·0 |
| Settle | 419 | 381 | 1 | — | 29 | 2 | 6 | 1·9 |
| Sheffield | 7,128 | 6,122 | 14 | 12 | 781 | 14 | 185 | 2·8 |
| Skipton | 1,158 | 910 | 2 | — | 123 | 59 | 64 | 10·6 |
| Tadcaster | 839 | 739 | 2 | — | 63 | 5 | 30 | 4·2 |
| Thorne | 431 | 348 | — | — | 51 | 7 | 25 | 7·4 |
| Wakefield | 3,323 | 2,860 | 4 | — | 358 | 22 | 79 | 3·0 |
| Wetherby | 339 | 289 | — | — | 30 | 7 | 13 | 5·9 |
| Wharfedale | 1,441 | 1,189 | 8 | — | 143 | 27 | 74 | 7·0 |
| Wortley | 1,286 | 1,131 | 2 | — | 122 | 1 | 30 | 2·4 |
| **ANGLESEY.** | | | | | | | | |
| Anglesey | 370 | 319 | — | — | 39 | 4 | 8 | 3·2 |
| Holyhead | 562 | 490 | — | — | 47 | 6 | 19 | 4·4 |
| **BRECKNOCK.** | | | | | | | | |
| Brecknock | 400 | 353 | — | — | 37 | 4 | 6 | 2·5 |
| Builth | 241 | 223 | — | — | 14 | 4 | — | 1·7 |
| Crickhowell | 669 | 583 | — | — | 74 | 2 | 10 | 1·8 |
| Hay | 297 | 264 | — | — | 29 | 1 | 3 | 1·3 |
| **CARDIGAN** | | | | | | | | |
| Aberayron | 319 | 297 | — | — | 14 | 2 | 6 | 2·5 |
| Aberystwith | 510 | 449 | — | — | 38 | 10 | 13 | 4·5 |
| Cardigan | 433 | 394 | — | — | 31 | 1 | 7 | 1·8 |
| Lampeter | 272 | 238 | — | — | 19 | 14 | 1 | 5·5 |
| Tregaron | 248 | 224 | — | — | 15 | 6 | 3 | 3·6 |
| **CARMARTHEN.** | | | | | | | | |
| Carmarthen | 958 | 859 | — | — | 86 | 3 | 10 | 1·4 |
| Llanelly | 1,616 | 1,400 | — | — | 122 | 63 | 31 | 5·8 |
| Llandilofawr | 560 | 498 | 2 | — | 51 | 3 | 6 | 1·6 |
| Llandovery | 311 | 276 | — | — | 30 | 2 | 3 | 1·6 |
| Newcastle-in-Emlyn | 501 | 467 | — | — | 33 | — | 1 | 0·2 |

App. A. No. 1.

Digest of Vaccination Officers' Returns.

| — | Returns, 1887. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Births. | Successfully Vaccinated. | Insusceptible of Vaccination. | Had Small-pox. | Died unvaccinated. | Vaccination postponed. | Remaining. | Children not finally accounted for (including cases postponed), per cent. of births. |
| **CARNARVON.** | | | | | | | | |
| Bangor and Beaumaris - | 1,050 | 941 | 1 | — | 90 | 5 | 13 | 1·7 |
| Carnarvon - - - | 1,104 | 935 | — | — | 128 | 12 | 29 | 3·7 |
| Conway - - - | 520 | 464 | — | — | 41 | 4 | 11 | 2·9 |
| Pwllheli - - - | 553 | 498 | — | — | 38 | 8 | 9 | 3·1 |
| **DENBIGH.** | | | | | | | | |
| Llanrwst - - - | 351 | 290 | 2 | — | 37 | 13 | 9 | 6·3 |
| Ruthin - - - | 322 | 287 | — | — | 29 | 4 | 2 | 1·9 |
| Wrexham - - - | 1,860 | 1,592 | 2 | — | 190 | 35 | 41 | 4·1 |
| **FLINT.** | | | | | | | | |
| Asaph, St. - - - | 708 | 619 | 1 | — | 60 | 4 | 24 | 4·0 |
| Hawarden - - - | 444 | 384 | — | — | 29 | 15 | 16 | 7·0 |
| Holywell - - - | 1,231 | 1,075 | — | — | 112 | 11 | 33 | 3·6 |
| **GLAMORGAN.** | | | | | | | | |
| Bridgend and Cowbridge - | 1,404 | 1,197 | — | 1 | 165 | 18 | 23 | 2·9 |
| Cardiff - - - | 5,494 | 4,540 | 15 | — | 563 | 29 | 347 | 6·8 |
| Gower - - - | 315 | 277 | — | — | 29 | 8 | 1 | 2·9 |
| Merthyr Tydfil - - | 3,599 | 3,249 | — | — | 277 | 17 | 56 | 2·0 |
| Neath - - - | 1,880 | 1,676 | — | — | 159 | 16 | 29 | 2·4 |
| Pontardawe - - - | 691 | 620 | — | — | 55 | 9 | 7 | 2·3 |
| Pontypridd - - - | 4,582 | 3,850 | 4 | — | 500 | 65 | 163 | 5·0 |
| Swansea - - - | 3,815 | 3,379 | 1 | — | 325 | 23 | 87 | 2·9 |
| **MERIONETH.** | | | | | | | | |
| Bala - - - - | 158 | 137 | — | — | 18 | 2 | 1 | 1·9 |
| Corwen - - - | 435 | 398 | — | — | 28 | 2 | 7 | 2·1 |
| Dolgelley - - - | 362 | 325 | — | — | 29 | 3 | 5 | 2·2 |
| Festiniog - - - | 883 | 757 | — | — | 108 | 13 | 5 | 2·0 |
| **MONTGOMERY.** | | | | | | | | |
| Llanfyllin - - - | 556 | 498 | 1 | — | 44 | 8 | 5 | 2·3 |
| Machynlleth - - | 249 | 224 | — | — | 21 | — | 4 | 1·6 |
| Forden - - - | 475 | 414 | — | — | 42 | 10 | 9 | 4·0 |
| Newtown and Llanidloes - | 623 | 540 | — | — | 64 | 5 | 14 | 3·0 |
| **PEMBROKE.** | | | | | | | | |
| Haverfordwest - - | 1,006 | 866 | — | — | 90 | 23 | 27 | 5·0 |
| Narberth - - - | 561 | 499 | — | — | 45 | 7 | 10 | 3·0 |
| Pembroke - - - | 1,134 | 957 | — | — | 122 | 30 | 25 | 4·9 |
| **RADNOR.** | | | | | | | | |
| Knighton - - - | 329 | 274 | — | — | 27 | 14 | 14 | 8·5 |
| Rhayader - - - | 178 | 157 | — | — | 11 | — | 10 | 5·6 |

## No. 2.

CONSIDERATIONS as to STATUTORY CERTIFICATES of "INSUSCEPTIBILITY" to VACCINATION; by the MEDICAL OFFICER.



THE following passage (from Medical Officer's 1887 Report) contains the experience of Dr. Cory, as to what is called "insusceptibility" of children to vaccination.

"P.S.—In accordance with your wish that I should record my experience of vaccinating children who have been certified as 'insusceptible,' I have to inform you that at various times four such cases have been sent to me at Surrey Chapel, and five to Lamb's Conduit Street, and that in every such case my first attempt at vaccination has succeeded. The resulting vesicles (whether done with human or with calf lymph) have been quite characteristic of vaccine, but eight of them were accelerated in their course in the same way that I have observed after a first unsuccessful operation by myself.

"Of my own vaccinations, I may say that I have in my time performed over 38,000 primary operations with human or with calf lymph; and that it has only once fallen to my lot to fail twice at an attempt at vaccination. The subject in this instance was a 10-year old child, in whom, as stated by its mother, vaccination had been attempted on previous occasions without result. My operation failed at the second attempt, and I did not get the opportunity of trying a third time.

"I believe the late Dr. Marson has recorded an identical experience from several thousands of operations performed at Blackfriars Station, where humanized lymph only was used."*

Dr. Cory has since furnished the Medical Department with further details as to his failures, complete and partial. They all are based upon experience of primary vaccinations with unstored lymph, each operation being performed by five superficial scratches.

Among some 16,000 first attempts at vaccination with humanized lymph, he has had 14 failures, being at the rate of one failure in 1,140 children operated on.

Of 22,041 first attempts at vaccination with calf lymph, he sets aside 44 cases vaccinated (successfully) for the cure of nævi, and 216 others that did not return for inspection. Among the 21,781 vaccinated on their arms with calf lymph, he has experienced 70 failures at a first attempt, being at the rate of one failure in 311 children operated on.

The vaccinations of this latter class, those from the calf, were therefore distinctly more difficult than those done from arm-to-arm. It is to this more difficult class that the next following figures relate:—

| | | | | |
|---|---|---|---|---|
| Five insertions succeeded in | | | 19,925 | instances. |
| Four | ,, | ,, | 1,011 | ,, |
| Three | ,, | ,, | 407 | ,, |
| Two | ,, | ,, | 224 | ,, |
| One | ,, | ,, | 144 | ,, |
| All insertions failed in | | | 70 | ,, |

It would appear from the above and other similar considerations that total failure in primary vaccination is explicable without recourse to

* I may properly point out that Dr. Cory does not here claim for himself any exceptional skill above his fellows. Reporting on his insertion success at the Animal Vaccine Station, again he tells of one of his colleagues getting results like his own, but a trifle better, during consecutive years.

App. A. No. 2.

Considerations as to Statutory Certificates of "Insusceptibility" to Vaccination; by the Medical Officer.

any hypothesis but that which suffices to explain partial failure; and this cannot, by the nature of the case, be an "insusceptibility" in the true sense of the word.

Nevertheless, there is a so-called "insusceptibility," with which, for practical purposes, vaccinators are concerned, namely, failure to obtain any vaccine vesicle in a given child after three several attempts at vaccination. This failure constitutes a *statutory* "insusceptibility," and it is desired to estimate in the present note how frequently a "certificate of insusceptibility," in this sense, is to be expected from one and another class of operator.

It has to be premised that a second attempt at vaccination of the same child is not quite so likely to succeed as a first attempt, and a third attempt is not quite so likely to succeed as a second. If it were not for this consideration, the probability of failure after three attempts would be once out of $x^3$ cases, where $x$ = the number of cases yielding one failure at a first attempt. But with allowance for the differing probability of success at repeated attempts to vaccinate, we must expect a failure at a third attempt to occur more often than once out of $x^3$ cases. If we can learn how much more often, we shall be able to foretell the probability of failure at a third attempt in the practice of any vaccinator for whom the quantity $x$ is known.

There are certain American experiences* which go to show the probability of failure at a third attempt to be once out of two-ninths of $x^3$; and there are some German experiences† which would place it at once out of one-ninth of $x^3$. There are no English experiences available for such an estimate.

Let us first use the assumption, derived from American experiences, that the probability of failure at a third attempt is once out of two-ninths of $x^3$.

Now, on the scale of success attained by Dr. Cory when vaccinating with calf lymph, $x = 311$, and $2\,x^3 \div 9 = 6{,}684{,}495$, and this would be the number of children who would be expected to furnish one child "insusceptible" in the statutory sense of the word. With humanised lymph, in Dr. Cory's practice, the number $x = 1{,}140$, and $2\,x^3 \div 9 = 329{,}232{,}000$, this being the number of children who would be expected to furnish one child "insusceptible" in a statutory sense.

Or, on a lesser scale of success (one that a practitioner, when vaccinating from arm-to-arm, may reasonably look to attain), say not more than one failure per 100 children submitted to operation, we should have $x = 100$, or $2\,x^3 \div 9 = 222{,}222$, as the number of children who would be expected to furnish one "insusceptible" child among them.

Or, if a vaccinator's scale of success were so unsatisfactory that, out of 20 attempted vaccinations, he habitually experienced one failure at the first attempt, it would be expected that a "certificate of insusceptibility" might be given as often as once for every 1,778 children presented to him for vaccination; but such a 5 per cent. of first failure, is only to be witnessed in the practice of those who vaccinate unskilfully or to an undue extent with preserved lymph.—A scale of failure amounting to once in every ten first attempts, cannot but be regarded as inexcusable; on that scale, the frequency of certificates of insusceptibility would be once in 222 cases submitted to vaccination.

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* Fifth and Sixth Reports of the Board of Health for New York, p. 120.

† Uebersicht der Ergebnisse des Impfgeschäftes im Deutschen Reiche für 1882; pp. 8–9, 16–17, 24–25; in the Report of the German Vaccination Commission of 1884.

From the above calculations, based on the assumption derived from American experience, let us pass to examine the question on the basis of the German experience, according to which the probability of failure at a third attempt is once out of one-ninth of $x^3$; and this would be the number to give one instance of what is here called "statutory insusceptibility."

Then, on Dr. Cory's scale of success, he would not have more than one insusceptible out of every 3,342,247 children whom he vaccinated with calf lymph, or more than one out of every 164,616,000 children whom he vaccinated with human lymph. On the next scale of success, a practitioner, having at his first attempt one per cent. of failure, might expect one "insusceptible" case out of 111,111 primary vaccinations. And on the unsatisfactory scale above considered, where there were no less than 5 per cent. of failures at the first attempt, a vaccinator would be expected to certify one case as "insusceptible" out of 889 children submitted to him:—while on the extravagant scale of one failure out of every ten first attempts the statutory "certificate of insusceptibility" would be given once out of 111 operations.

App. A. No. 3.

Inspection of Public Vaccination.

## No. 3.

List (alphabetically arranged) of 273 Unions inspected during the Year 1889, with reference to the Proceedings under the Vaccination Acts, 1867 and 1871, and an Account of the Awards made to the respective Public Vaccinators.

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. | | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | Minimum. | Maximum. | | |
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Aberayron - - | 2 | 2 | 10 3 0 | 12 0 0 | 22 3 0 | Mr. Spear. |
| Aberystwith - - | 5 | 4 | 5 17 0 | 15 3 0 | 39 17 0 | Do. |
| Albans, St. - - | 4 | 2 | 21 7 0 | 28 6 0 | 49 13 0 | Dr. BruceLow. |
| Alcester - - - | 5 | 5 | 3 14 0 | 10 10 0 | 37 3 0 | „ Parsons. |
| Alston-with-Garrigill - | 2 | 2 | 3 3 0 | 3 5 0 | 6 8 0 | „ Page. |
| Anglesey - - - | 3 | 2 | 7 10 0 | 9 5 0 | 16 15 0 | „ Parsons. |
| Asaph, St. - - - | 5 | 2 | 12 17 0 | 13 8 0 | 26 5 0 | Do. |
| Ashford, East - - | 6 | 6 | 1 19 0 | 7 13 0 | 30 19 0 | „ Stevens. |
| Ashford, West - - | 4 | 4 | 0 18 0 | 13 12 0 | 24 2 0 | Do. |
| Aston - - - | 7 | 7 | 7 10 0 | 83 1 0 | 309 15 0 | „ Parsons. |
| Atherstone - - | 2 | 1 | — | — | 23 7 0 | Do. |
| Axbridge - - - | 11 | 5 | 1 18 0 | 16 16 0 | 38 16 0 | „ Blaxall. |
| Axminster - - | 12 | 2 | 0 16 0 | 2 4 0 | 3 0 0 | „ BruceLow. |
| Bala - - - | 1 | — | — | — | — | Dr. Parsons. |
| Bangor and Beaumaris - | 6 | 3 | 2 8 0 | 16 6 0 | 27 6 0 | Do. |
| Barnet - - - | 5 | 2 | 3 2 0 | 13 10 0 | 16 12 0 | „ BruceLow. |
| Barnsley - - - | 5 | 5 | 21 17 0 | 86 19 0 | 251 9 0 | „ Barry. |
| Barnstaple - - | 11 | 7 | 0 9 0 | 22 4 0 | 44 10 0 | „ Ballard. |
| Barrow-in-Furness - | 1 | 1 | — | — | 112 19 0 | „ Page. |
| Barton Regis - - | 6 | 6 | 18 12 0 | 63 7 0 | 175 12 0 | „ Blaxall. |
| Basford - - - | 13 | 10 | 6 3 0 | 60 14 0 | 263 5 0 | „ BruceLow |
| Bath - - - | 5 | 4 | 9 15 0 | 22 7 0 | 59 2 0 | „ Blaxall. |
| Battle - - - | 6 | 6 | 1 5 0 | 13 8 0 | 29 12 0 | „ Stevens. |
| Bedminster - - | 9 | 3 | 4 12 0 | 8 14 0 | 18 15 0 | „ Blaxall. |
| Berkhampstead - - | 3 | 2 | 8 9 0 | 20 15 0 | 29 4 0 | „ BruceLow, |
| Bethnal Green - - | 2 | 2 | 51 18 0 | 172 17 0 | 224 15 0 | „ Airy. |
| Bideford - - - | 6 | 4 | 0 10 0 | 16 0 0 | 28 3 0 | „ Ballard. |

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. Minimum. | Range of Awards in each Union. Maximum. | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Billericay | 4 | 4 | 3 16 0 | 22 10 0 | 43 19 0 | Dr. Airy. |
| Bingham | 4 | 3 | 4 7 0 | 6 5 0 | 15 18 0 | „ BruceLow. |
| Birmingham | 1 | 1 | — | — | 199 15 0 | „ Stevens. |
| Bishop Stortford | 7 | 4 | 5 12 0 | 14 4 0 | 37 0 0 | „ BruceLow. |
| Blean | 4 | 4 | 4 15 0 | 15 4 0 | 35 17 0 | „ Stevens. |
| Blything | 8 | 7 | 6 9 0 | 12 19 0 | 66 2 0 | „ Airy. |
| Bootle | 3 | 3 | 4 11 0 | 12 8 0 | 21 14 0 | „ Page. |
| Bosmere and Claydon | 3 | 2 | 13 5 0 | 18 1 0 | 31 6 0 | „ Airy. |
| Bradford (Wilts) | 3 | — | — | — | — | „ Blaxall. |
| Bradford (Yorks) | 4 | 4 | 39 1 0 | 72 0 0 | 224 15 0 | „ Barry. |
| Bramley | 4 | 3 | 4 6 0 | 29 17 0 | 41 5 0 | Do. |
| Brampton | 1 | 1 | — | — | 17 12 0 | „ Page. |
| Brecknock | 3 | 2 | 6 1 0 | 8 18 0 | 14 19 0 | Mr. Spear. |
| Bridge | 5 | 5 | 2 16 0 | 7 9 0 | 23 16 0 | Dr. Stevens. |
| Bridgwater | 10 | 3 | 1 18 0 | 9 2 0 | 13 11 0 | „ Blaxall. |
| Brighton | 2 | 2 | 35 9 0 | 37 17 0 | 73 6 0 | „ Stevens. |
| Bristol | 1 | 1 | — | — | 27 15 0 | Do. |
| Bromley | 6 | 5 | 1 1 0 | 20 12 0 | 39 15 0 | Do. |
| Builth | 1 | 1 | — | — | 18 1 0 | Mr. Spear. |
| Buntingford | 2 | 2 | 5 15 0 | 7 11 0 | 13 6 0 | Dr. BruceLow. |
| Bury St. Edmunds | 1 | 1 | — | — | 34 8 0 | „ Airy. |
| Canterbury | 1 | 1 | — | — | 25 0 0 | Dr. Stevens. |
| Cardiff | 8 | 6 | 0 16 0 | 89 15 0 | 170 2 0 | Mr. Spear. |
| Cardigan | 3 | 3 | 9 18 0 | 14 17 0 | 38 9 0 | Do. |
| Carlisle | 5 | 5 | 2 8 0 | 63 1 0 | 77 18 0 | Dr. Page. |
| Carmarthen | 6 | 4 | 9 15 0 | 22 10 0 | 57 14 0 | Mr. Spear. |
| Carnarvon | 4 | 2 | 6 5 0 | 27 3 0 | 33 8 0 | Dr. Parsons. |
| Chailey | 4 | 3 | 1 5 0 | 8 12 0 | 15 1 0 | „ Stevens. |
| Chard | 7 | 5 | 6 6 0 | 14 2 0 | 48 14 0 | „ Blaxall. |
| Chelsea | 2 | 2 | 33 7 0 | 75 13 0 | 109 0 0 | „ Airy. |
| Cheltenham | 3 | 1 | — | — | 40 6 0 | „ Blaxall. |
| Chester | 3 | 2 | 4 11 0 | 69 2 0 | 73 13 0 | „ Page. |
| Chester-le-Street | 4 | 3 | 9 0 0 | 27 11 0 | 61 12 0 | Do. |
| Chichester | 1 | — | — | — | — | „ Stevens. |
| Chipping Sodbury | 5 | 2 | 6 18 0 | 8 0 0 | 14 18 0 | „ Blaxall. |
| Cirencester | 5 | 2 | 1 16 0 | 19 18 0 | 21 14 0 | „ Blaxall. |
| Cockermouth | 5 | 2 | 4 18 0 | 8 10 0 | 13 8 0 | „ Page. |

App. A No. 3.

Inspection of Public Vaccination.

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. Minimum. | Range of Awards in each Union. Maximum. | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Colchester - - | 1 | 1 | — | — | 59 17 0 | Dr. Airy. |
| Conway - - - | 3 | 3 | 9 3 0 | 14 1 0 | 35 13 0 | „ Parsons. |
| Corwen - - - | 3 | 2 | 4 1 0 | 16 19 0 | 21 0 0 | Do. |
| Cosford - - - | 5 | 5 | 6 1 0 | 13 10 0 | 49 12 0 | „ Airy. |
| Cranbrook - - | 6 | 5 | 1 9 0 | 5 2 0 | 17 9 0 | „ Stevens. |
| Crediton - - - | 11 | 4 | 1 12 0 | 6 11 0 | 14 16 0 | „ BruceLow. |
| Crickhowell - - | 2 | 2 | 8 10 0 | 39 4 0 | 47 14 0 | Mr. Spear. |
| Cricklade and Wootton Bassett. | 3 | — | — | — | — | Dr. Blaxall. |
| Cuckfield - - - | 6 | 6 | 2 5 0 | 9 2 0 | 38 19 0 | „ Stevens. |
| Dartford - - - | 5 | 4 | 15 3 0 | 21 6 0 | 68 12 0 | Dr. Stevens. |
| Derby - - - | 2 | 2 | 56 15 0 | 88 9 0 | 145 4 0 | „ Page. |
| Devizes - - - | 6 | 3 | 3 18 0 | 8 17 0 | 19 15 0 | „ Blaxall. |
| Dolgelley - - - | 5 | 4 | 4 3 0 | 10 0 0 | 24 18 0 | „ Parsons. |
| Dover - - - | 4 | 4 | 2 5 0 | 29 11 0 | 43 16 0 | „ Stevens. |
| Dulverton - - - | 3 | 3 | 1 5 0 | 3 19 0 | 6 10 0 | „ Blaxall. |
| Durham - - - | 5 | 4 | 13 12 0 | 42 9 0 | 90 13 0 | „ Page. |
| Dursley - - - | 3 | 3 | 3 2 0 | 12 6 0 | 26 3 0 | „ Blaxall. |
| Easington - - - | 5 | 5 | 5 15 0 | 47 18 0 | 133 18 0 | Dr. Page. |
| Easingwold - - | 4 | 3 | 5 16 0 | 11 2 0 | 27 3 0 | „ Barry. |
| Eastbourne - - | 4 | 4 | 1 19 0 | 17 7 0 | 27 2 0 | „ Stevens. |
| East Grinstead - - | 6 | 5 | 3 4 0 | 9 5 0 | 33 19 0 | Do. |
| East Preston - - | 3 | 3 | 6 17 0 | 23 0 0 | 40 4 0 | Do. |
| East Retford - - | 6 | 2 | 2 1 0 | 7 0 0 | 9 1 0 | „ BruceLow. |
| Eastry - - - | 7 | 5 | 3 3 0 | 12 8 0 | 34 4 0 | „ Stevens. |
| East Stonehouse - - | 1 | 1 | — | — | 32 10 0 | „ BruceLow. |
| East Ward - - | 6 | 5 | 1 4 0 | 6 1 0 | 19 4 0 | „ Page. |
| Elham - - - | 5 | 5 | 1 19 0 | 37 9 0 | 61 13 0 | „ Stevens. |
| Epping - - - | 9 | 5 | 6 3 0 | 19 14 0 | 50 2 0 | „ Airy. |
| Exeter - - - | 1 | 1 | — | — | 36 10 0 | „ Stevens. |
| Faversham - - | 4 | 4 | 2 19 0 | 36 9 0 | 54 12 0 | Dr. Stevens. |
| Festiniog - - - | 3 | 1 | — | — | 6 7 0 | „ Parsons. |
| Foleshill - - - | 5 | 2 | 7 16 0 | 12 11 0 | 20 7 0 | Do. |
| Forden - - - | 4 | 4 | 1 14 0 | 8 12 0 | 22 5 0 | Do. |

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. Minimum. | Range of Awards in each Union. Maximum. | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | £ s. d. | £ s. d. | £ s. d. | |
| George, St., East | 1 | 1 | — | — | 99 2 0 | Dr. Airy. |
| Gloucester | 2 | — | — | — | — | „ Blaxall. |
| Gower | 2 | 1 | — | — | 8 4 0 | Mr. Spear. |
| Gravesend and Milton | 1 | 1 | — | — | 19 13 0 | Dr. Stevens. |
| Hackney | 4 | 4 | 23 8 0 | 64 18 0 | 180 1 0 | Dr. Airy. |
| Hailsham | 7 | 7 | 2 10 0 | 5 9 0 | 29 13 0 | „ Stevens. |
| Halifax | 9 | 8 | 3 2 0 | 78 8 0 | 174 12 0 | „ Barry. |
| Halstead | 5 | 4 | 4 16 0 | 18 13 0 | 43 4 0 | „ Airy. |
| Haltwhistle | 4 | 4 | 0 9 0 | 4 2 0 | 8 3 0 | „ Page. |
| Hartlepool | 3 | 2 | 35 6 0 | 44 13 0 | 79 19 0 | Do. |
| Hastings | 2 | 2 | 1 11 0 | 53 3 0 | 54 14 0 | „ Stevens. |
| Hatfield | 3 | — | — | — | — | „ BruceLow. |
| Haverfordwest | 4 | — | — | — | — | Mr. Spear. |
| Hawarden | 3 | 1 | — | — | 10 10 0 | Dr. Parsons. |
| Hay | 3 | 3 | 4 15 0 | 6 16 0 | 18 4 0 | Mr. Spear. |
| Hemel Hempstead | 4 | 4 | 6 7 0 | 13 1 0 | 39 3 0 | Dr. BruceLow. |
| Hertford | 5 | 1 | — | — | 5 9 0 | Do. |
| Hexham | 11 | 11 | 0 5 0 | 12 7 0 | 48 11 0 | „ Page. |
| Highworth and Swindon | 4 | 1 | — | — | 10 17 0 | „ Blaxall. |
| Hitchin | 5 | 4 | 10 19 0 | 25 18 0 | 62 10 0 | „ BruceLow. |
| Holbeck | 1 | 1 | — | — | 36 19 0 | „ Barry. |
| Hollingbourn | 6 | 5 | 2 1 0 | 7 17 0 | 23 0 0 | „ Stevens. |
| Holsworthy | 5 | 3 | 1 7 0 | 10 2 0 | 14 10 0 | „ BruceLow. |
| Holyhead | 3 | 2 | 9 16 0 | 10 13 0 | 20 9 0 | „ Parsons. |
| Holywell | 5 | 3 | 9 0 0 | 25 10 0 | 52 16 0 | Do. |
| Honiton | 12 | 3 | 8 14 0 | 11 17 0 | 31 6 0 | „ BruceLow. |
| Hoo | 1 | 1 | — | — | 10 18 0 | „ Stevens. |
| Horsham | 8 | 7 | 2 6 0 | 16 10 0 | 41 0 0 | Do. |
| Houghton-le-Spring | 3 | 3 | 12 6 0 | 23 13 0 | 55 11 0 | „ Page. |
| Islington | 5 | 5 | 32 4 0 | 52 0 0 | 208 7 0 | Dr. Airy. |
| Keighley | 4 | 4 | 0 12 0 | 7 18 0 | 11 19 0 | Dr. Barry. |
| Kendal | 9 | 7 | 2 9 0 | 14 14 0 | 47 10 0 | „ Page. |
| Keynsham | 1 | 1 | — | — | 90 0 0 | „ Blaxall. |
| Kingsbridge | 5 | 4 | 1 6 0 | 19 10 0 | 32 3 0 | „ BruceLow. |
| Knaresborough | 3 | 3 | 3 4 0 | 16 17 0 | 35 13 0 | „ Barry. |
| Knighton | 5 | 2 | 4 6 0 | 5 12 0 | 9 18 0 | Mr. Spear. |

App. A. No. 8.

Inspection of Public Vaccination.

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. | | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | Minimum. | Maximum. | | |
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Lambeth | 5 | 5 | 17 13 0 | 86 3 0 | 250 2 0 | Dr. Airy. |
| Lampeter | 2 | 1 | — | — | 14 17 0 | Mr. Spear. |
| Lancaster | 5 | 3 | 8 8 0 | 46 11 0 | 63 13 0 | Dr. Page. |
| Lanchester | 4 | 4 | 10 7 0 | 43 18 0 | 101 12 0 | Do. |
| Langport | 6 | 2 | 5 4 0 | 6 11 0 | 11 15 0 | „ Blaxall. |
| Leeds | 7 | 6 | 1 13 0 | 41 5 0 | 112 0 0 | „ Stevens. |
| Lewes | 1 | 1 | — | — | 14 7 0 | Do. |
| Lewisham | 5 | 3 | 5 19 0 | 24 16 0 | 46 11 0 | „ Airy. |
| Liverpool | 3 | 3 | 36 1 0 | 66 15 0 | 147 5 0 | „ Page. |
| Llandilofawr | 5 | 3 | 4 17 0 | 12 19 0 | 23 3 0 | Mr. Spear. |
| Llandovery | 2 | 2 | 8 4 0 | 14 7 0 | 22 11 0 | Do. |
| Llanelly | 3 | 3 | 18 14 0 | 78 15 0 | 123 19 0 | Do. |
| Llanfyllin | 5 | 4 | 5 6 0 | 11 8 0 | 35 0 0 | Dr. Parsons. |
| Llanrwst | 2 | 1 | — | — | 11 2 0 | Do. |
| London, City | 2 | 1 | — | — | 13 4 0 | „ Airy. |
| Longtown | 2 | 1 | — | — | 8 6 0 | „ Page. |
| Lunesdale | 4 | 2 | 0 4 0 | 1 10 0 | 1 14 0 | Do. |
| Machynlleth | 4 | 3 | 4 1 0 | 5 18 0 | 15 10 0 | Dr. Parsons. |
| Maidstone | 5 | 5 | 3 18 0 | 42 11 0 | 72 11 0 | „ Stevens. |
| Malling | 5 | 5 | 8 0 0 | 21 5 0 | 62 18 0 | Do. |
| Malmesbury | 4 | — | — | — | — | „ Blaxall. |
| Malton | 6 | 4 | 3 8 0 | 11 12 0 | 27 11 0 | „ Barry. |
| Manchester | 3 | 3 | 34 18 0 | 62 10 0 | 153 13 0 | „ Page. |
| Mansfield | 6 | 3 | 7 12 0 | 25 4 0 | 44 1 0 | „ BruceLow. |
| Marlborough | 2 | 2 | 3 13 0 | 15 1 0 | 18 14 0 | „ Blaxall. |
| Marylebone | 2 | 2 | 63 0 0 | 81 14 0 | 144 14 0 | „ Airy. |
| Medway | 3 | 3 | 25 17 0 | 58 6 0 | 127 6 0 | „ Stevens. |
| Mere | 2 | 1 | — | — | 4 7 0 | „ Blaxall. |
| Meriden | 3 | 3 | 2 14 0 | 6 4 0 | 14 11 0 | „ Parsons. |
| Merthyr Tydfil | 10 | 9 | 4 18 0 | 59 3 0 | 259 3 0 | Mr. Spear. |
| Midhurst | 5 | 4 | 3 5 0 | 10 1 0 | 22 5 0 | Dr. Stevens. |
| Mildenhall | 2 | 1 | — | — | 9 17 0 | „ Airy. |
| Mile End Old Town | 2 | 1 | — | — | 93 5 0 | Do. |
| Milton | 2 | 2 | 13 6 0 | 38 4 0 | 51 10 0 | „ Stevens. |
| Mutford and Lothingland. | 3 | 2 | 34 17 0 | 69 1 0 | 103 18 0 | „ Airy. |

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. | | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | Minimum. | Maximum. | | |
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Narberth - - - | 4 | 2 | 11 15 0 | 12 18 0 | 24 13 0 | Mr. Spear. |
| Neath - - - | 6 | 3 | 3 16 0 | 28 12 0 | 54 11 0 | Do. |
| Newark - - - | 9 | 8 | 1 0 0 | 31 6 0 | 49 13 0 | Dr. BruceLow. |
| Newcastle-in-Emlyn - | 3 | 3 | 10 6 0 | 18 7 0 | 43 11 0 | Mr. Spear. |
| Newcastle-on-Tyne - | 3 | 4 | 28 17 0 | 64 5 0 | 168 19 0 | Dr. Stevens. |
| Newent - - - | 3 | 3 | 7 14 0 | 12 9 0 | 28 6 0 | „ Blaxall. |
| Newhaven - - | 5 | 4 | 0 10 0 | 4 13 0 | 8 11 0 | „ Stevens. |
| Newton Abbot - - | 12 | 5 | 5 3 0 | 29 9 0 | 63 5 0 | „ Bruce Low. |
| Newtown and Llanidloes | 4 | 2 | 4 16 0 | 14 17 0 | 19 13 0 | „ Parsons. |
| Northleach - - | 4 | 1 | — | — | 5 9 0 | „ Blaxall. |
| Nottingham - - | 3 | 2 | 67 17 0 | 73 3 0 | 141 0 0 | „ BruceLow. |
| Nuneaton - - - | 2 | 1 | — | — | 7 0 0 | „ Parsons. |
| Okehampton - - | 6 | 2 | 4 10 0 | 6 15 0 | 11 5 0 | Dr. Ballard. |
| Oundle - - - | 4 | 1 | — | — | 8 11 0 | „ Parsons. |
| Pancras, St. - - | 1 | 1 | — | — | 199 13 0 | Dr. Airy. |
| Pembroke - - - | 6 | 3 | 6 8 0 | 33 18 0 | 49 18 0 | Mr. Spear. |
| Penrith - - - | 6 | 3 | 3 10 0 | 4 19 0 | 12 17 0 | Dr. Page. |
| Peterborough - - | 7 | 6 | 2 8 0 | 67 19 0 | 128 11 0 | „ Parsons. |
| Petworth - - - | 4 | 3 | 1 6 0 | 6 12 0 | 10 11 0 | „ Stevens. |
| Pewsey - - - | 5 | 2 | 3 15 0 | 9 10 0 | 13 5 0 | „ Blaxall. |
| Plomesgate - - | 6 | 6 | 5 14 0 | 11 14 0 | 50 18 0 | „ Airy. |
| Plymouth - - - | 1 | 2 | 57 2 0 | 60 14 0 | 117 16 0 | „ Ballard. |
| Plympton St. Mary - | 5 | 4 | 6 1 0 | 8 15 0 | 28 8 0 | „ Bruce Low. |
| Pontardawe - - | 2 | 2 | 29 5 0 | 31 8 0 | 60 13 0 | Mr. Spear. |
| Pontypridd - - | 9 | 6 | 9 8 0 | 64 19 0 | 185 11 0 | Do. |
| Pwllheli - - - | 5 | 2 | 4 12 0 | 5 6 0 | 9 18 0 | Dr. Parsons. |
| Rhayader - - - | 2 | 2 | 5 4 0 | 8 19 0 | 14 3 0 | Mr. Spear. |
| Ripon - - - | 4 | 2 | 4 8 0 | 12 15 0 | 17 3 0 | Dr. Barry. |
| Risbridge - - - | 5 | 4 | 3 12 0 | 8 15 0 | 25 19 0 | „ Airy. |
| Romford - - - | 7 | 5 | 2 14 0 | 54 13 0 | 144 13 0 | Do. |
| Romney Marsh - - | 3 | 2 | 0 19 0 | 7 3 0 | 8 2 0 | „ Stevens. |
| Rotherham - - | 8 | 6 | 4 8 0 | 80 16 0 | 170 7 0 | „ Barry. |
| Royston - - - | 6 | 4 | 7 4 0 | 18 17 0 | 46 5 0 | „ BruceLow. |
| Rugby - - - | 8 | 4 | 1 10 0 | 6 8 0 | 14 15 0 | „ Parsons. |
| Ruthin - - - | 3 | 1 | — | — | 6 0 0 | Do. |
| Rye - - - | 3 | 3 | 4 12 0 | 14 14 0 | 25 0 0 | „ Stevens. |

App. A. No. 3.

Inspection of Public Vaccination.

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. | | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | Minimum. | Maximum. | | |
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Salford - - - | 4 | 4 | 24 18 0 | 55 5 0 | 163 4 0 | Dr. Page. |
| Samford - - - | 4 | 1 | — | — | 5 1 0 | „ Airy. |
| Sculcoates - - - | 6 | 5 | 3 1 0 | 88 10 0 | 214 16 0 | „ Barry. |
| Sedgefield - - - | 4 | 4 | 7 10 0 | 11 17 0 | 38 11 0 | „ Page. |
| Settle - - - | 7 | 5 | 0 9 0 | 7 6 0 | 12 16 0 | „ Barry. |
| Sevenoaks - - - | 6 | 5 | 2 11 0 | 9 3 0 | 35 17 0 | „ Stevens. |
| Shaftesbury - - | 3 | 1 | — | — | 17 1 0 | „ Blaxall. |
| Sheffield - - - | 6 | 6 | 10 2 0 | 40 11 0 | 170 3 0 | „ Stevens. |
| Sheppey - - - | 2 | 2 | 7 18 0 | 26 17 0 | 34 15 0 | Do. |
| Skipton - - - | 8 | 6 | 3 10 0 | 15 11 0 | 46 1 0 | „ Barry. |
| Solihull - - - | 4 | 4 | 4 6 0 | 12 11 0 | 30 6 0 | „ Parsons. |
| Southam - - - | 4 | 2 | 6 7 0 | 10 3 0 | 60 10 0 | Do. |
| Southmolton - - | 9 | 3 | 3 19 0 | 7 12 0 | 11 11 0 | „ Ballard. |
| South Shields - - | 3 | 3 | 21 17 0 | 90 1 0 | 179 15 0 | „ Page. |
| Southwell - - - | 7 | 7 | 1 1 0 | 8 15 0 | 33 3 0 | „ BruceLow. |
| Steyning - - - | 6 | 5 | 5 8 0 | 26 1 0 | 56 6 0 | „ Stevens. |
| Stockton - - - | 3 | 3 | 6 17 0 | 43 2 0 | 60 17 0 | „ Page. |
| Stoke Damerel - - | 2 | 1 | — | — | 35 2 0 | „ Ballard. |
| Stow (Suffolk) - - | 7 | 6 | 2 7 0 | 12 17 0 | 47 5 0 | „ Airy. |
| Stow-on-the-Wold - | 2 | 1 | — | — | 9 1 0 | „ Blaxall. |
| Stratford-on-Avon - | 7 | 2 | 7 0 0 | 15 17 0 | 22 17 0 | „ Parsons. |
| Strood - - - | 2 | 2 | 27 19 0 | 37 7 0 | 65 6 0 | „ Stevens. |
| Stroud - - - | 6 | 4 | 12 8 0 | 34 1 0 | 80 5 0 | „ Blaxall. |
| Sturminster - - | 4 | 3 | 3 13 0 | 13 16 0 | 23 9 0 | Do. |
| Sudbury - - - | 7 | 6 | 1 15 0 | 21 18 0 | 61 3 0 | „ Airy. |
| Sunderland - - | 5 | 5 | 6 3 0 | 74 9 0 | 246 6 0 | „ Page. |
| Swansea - - - | 5 | 4 | 20 4 0 | 83 7 0 | 203 17 0 | Mr. Spear. |
| Tavistock - - - | 8 | 4 | 7 8 0 | 15 17 0 | 44 14 0 | Dr. BruceLow. |
| Tendring - - - | 11 | 8 | 2 5 0 | 29 15 0 | 87 14 0 | „ Airy. |
| Tenterden - - - | 6 | 5 | 2 16 0 | 6 9 0 | 21 7 0 | „ Stevens. |
| Tetbury - - - | 2 | 1 | — | — | 11 9 0 | „ Blaxall. |
| Tewkesbury - - | 4 | 1 | — | — | 3 16 0 | Do. |
| Thakeham - - - | 2 | 2 | 8 8 0 | 10 9 0 | 18 17 0 | „ Stevens. |
| Thanet, Isle of - - | 4 | 4 | 7 19 0 | 42 9 0 | 92 15 0 | Do. |
| Thingoe - - - | 8 | 8 | 1 14 0 | 7 6 0 | 41 9 0 | „ Airy. |
| Thomas, St. - - | 17 | 9 | 1 5 0 | 21 19 0 | 58 9 0 | „ BruceLow. |

| UNION. | No. of Vaccination Districts in the Union. | No. of Public Vaccinators recommended for Award. | Range of Awards in each Union. Minimum. | Range of Awards in each Union. Maximum. | Total Sum awarded in each Union. | Inspector. |
|---|---|---|---|---|---|---|
| | | | £ s. d. | £ s. d. | £ s. d. | |
| Thornbury - - | 4 | 2 | 2 3 0 | 15 1 0 | 17 4 0 | Dr. Blaxall. |
| Ticehurst - - - | 8 | 8 | 0 13 0 | 8 4 0 | 33 0 0 | „ Stevens. |
| Tiverton - - - | 13 | 6 | 0 12 0 | 15 8 0 | 36 11 0 | „ BruceLow. |
| Tonbridge - - - | 6 | 4 | 5 17 0 | 11 9 0 | 35 2 0 | „ Stevens. |
| Torrington - - | 5 | 2 | 5 9 0 | 9 6 0 | 14 15 0 | „ Ballard. |
| Totnes - - - | 11 | 6 | 1 5 0 | 14 18 0 | 34 19 0 | „ BruceLow. |
| Toxteth Park - - | 2 | 2 | 31 18 0 | 43 2 0 | 75 0 0 | „ Page. |
| Tregaron - - - | 2 | 2 | 8 1 0 | 11 4 0 | 19 5 0 | Mr. Spear. |
| Tynemouth - - | 7 | 7 | 19 0 0 | 42 9 0 | 203 18 0 | Dr. Page. |
| Uckfield - - - | 6 | 6 | 1 12 0 | 11 0 0 | 44 16 0 | Dr. Stevens. |
| Ulverston - - - | 7 | 6 | 3 9 0 | 40 8 0 | 87 19 0 | „ Page. |
| Wandsworth and Clapham. | 7 | 3 | 13 13 0 | 104 19 0 | 149 18 0 | Dr. Airy. |
| Wangford - - - | 2 | 2 | 14 6 0 | 27 2 0 | 41 8 0 | Do. |
| Ware - - - | 8 | 6 | 1 3 0 | 15 15 0 | 37 9 0 | „ BruceLow. |
| Warwick - - - | 3 | 2 | 13 4 0 | 33 10 0 | 46 14 0 | „ Parsons. |
| Watford - - - | 4 | 3 | 8 8 0 | 18 13 0 | 38 12 0 | „ Bruce Low. |
| Wellington (Som.) - | 5 | 4 | 4 1 0 | 6 9 0 | 22 1 0 | „ Blaxall. |
| Welwyn - - - | 1 | 1 | — | — | 3 1 0 | „ Bruce Low. |
| Westbourne - - | 2 | 2 | 1 6 0 | 7 5 0 | 8 11 0 | „ Stevens. |
| Westbury-on-Severn - | 4 | 3 | 8 14 0 | 26 11 0 | 47 9 0 | „ Blaxall. |
| West Derby - - | 7 | 7 | 12 14 0 | 100 18 0 | 299 11 0 | „ Page. |
| West Firle - - | 3 | 3 | 0 18 0 | 2 11 0 | 4 19 0 | „ Stevens. |
| Westhampnett - - | 5 | 5 | 3 11 0 | 15 18 0 | 38 15 0 | Do. |
| West Ward - - | 4 | 2 | 2 12 0 | 3 11 0 | 6 3 0 | „ Page. |
| Wharfedale - - | 3 | 2 | 16 14 0 | 17 15 0 | 34 9 0 | „ Barry. |
| Wheatenhurst - - | 2 | 2 | 6 13 0 | 11 17 0 | 18 10 0 | „ Blaxall. |
| Whitehaven - - | 6 | 5 | 16 15 0 | 38 16 0 | 114 1 0 | „ Page. |
| Wigton - - - | 6 | 2 | 5 10 0 | 6 5 0 | 11 15 0 | Do. |
| Williton - - - | 7 | 4 | 1 5 0 | 10 11 0 | 22 9 0 | „ Blaxall. |
| Winchcomb - - | 2 | — | — | — | — | Do. |
| Woolwich - - | 4 | 4 | 4 15 0 | 72 15 0 | 133 7 0 | „ Airy. |
| Worksop - - - | 7 | 6 | 2 0 0 | 29 3 0 | 71 16 0 | „ BruceLow. |
| Wrexham - - - | 5 | 3 | 6 19 0 | 54 9 0 | 103 0 0 | „ Parsons. |
| Total - - | 1,263 | 898 | — | — | 15,041 13 0 | |

App. A. No. 4.

National Vaccine Establishment.

## No. 4.

## Statistics of the National Vaccine Establishment and Educational Vaccination Stations.

### I.—Staff at end of 1889.

N.B.—The Stations named in *italics* are Educational Vaccination Stations authorised by the Local Government Board.

| Description of Vaccinators. | Name of Vaccinator. | Vaccination Stations. | Days and Hours of Attendance. |
|---|---|---|---|
| Vaccinators supplying lymph for the public service, & salaried from the Parliamentary grant. | 1. Dr. R Cory | *Surrey Chapel* | Tues., Thurs.; 2. |
| | 2. Mr. W. E. G. Pearse | *Tottenham Court Chapel.* | Mon., Wednes.; 1. |
| Parochial and other Vaccinators not salaried from the Parliamentary grant, but contributing lymph at a fixed rate of payment. | 1. Mr. Ellis S. Guest | *Manchester* | Monday; 2. |
| | 2–6. Dr. Edmund Robinson. | *Birmingham* | Monday, Tuesday, Wednesday 11.; Wednesday; 2. Thursday; 11. |
| | 7. Mr. Roger Parker | *Liverpool* | Tuesday; 2.30. |
| | 8. Mr. E. L. Webb | *Pimlico* | Thursday; 10. |
| | 9. Mr. J. Hawthorn | *Newcastle-on-Tyne.* | Wednesday; 3. |
| | 10. Mr. W. E. G. Pearse | *Westminster* | Tuesday; 10. |
| | 11–12. Mr. E. C. Greenwood | *Marylebone* | Tuesday; 2. Wednesday; 10. |
| | 13. Mr. J. Loane | *Whitechapel* | Wednesday; 11. |
| | 14. Mr. Frederick Holmes | *Leeds* | Tuesday; 2.30. |
| | 15. Dr. Edward Lynes | Coventry | Tuesday; 12. |
| | 16–17. Dr. Hugh Thomson | *Glasgow* | Monday; 2. Mon., Thurs.; 12. |
| | 18. Mr. J. F. Staines | *Endell Street* | Tuesday; 11. |
| | 19. Mr. W. Skinner | *Sheffield* | Tuesday; 3. |
| | 20. Dr. A. C. Clarke | Salford | Thursday; 2. |
| | 21. Dr. G. A. Miskin | Waterloo | Tuesday; 2. |
| | 22. Dr. J. B. Buist | *Edinburgh* | Thursday; 3. |
| | 23. Dr. R. Cory | *St. Thomas's Hosp.* | Wednesday; 11.30. |
| | 24. Dr. D. C. McVail | *Glasgow West* | Monday; 1. |
| Teachers of Vaccination not supplying lymph. | Dr. W. Husband | *Edinburgh* | Wednes., Sat.; 12. |
| | Mr. H. Lawrence | *Bristol* | Wednesday; 10. |
| | Mr. William A. Budd | *Exeter* | Thursday; 3. |
| | Mr. V. A. Jaynes | *Horsleydown* | Wednesday; 3. |
| | Dr. A. N. Montgomery | *Dublin* | Tues., Fri.; 10. |
| | Dr. R. Cory | *Cambridge* | Friday; 11. |

## II.—Animal Vaccine Station.



The Animal Vaccine Station is at 95, Lamb's Conduit Street, where Dr. R. Cory and Mr T. S. Stott attend for the Vaccination of Children on Tuesdays and Thursdays, at 10.30 a.m.

## III.—Sources and Amount of Lymph Supply in 1889.

N.B.—The Stations named in *italics* are Educational Vaccination Stations authorised by the Local Government Board.

| Description of Vaccinators. | Vaccination Stations. | Number of Vaccinations performed at the Stations respectively. | | Number of Charges of Lymph supplied from the Stations respectively. | |
|---|---|---|---|---|---|
| | | Primary. | Re-vaccinations. | Charged Ivory Points. | Charged Tubes each estimated as equal to 10 Ivory Points. |
| Vaccinators salaried from the Parliamentary grant. | 1. *Surrey Chapel* | 235 | 11 | 631 | — |
| | 2. *Tottenham Court Chapel.* | 371 | 1 | — | 129 |
| | Total - | 606 | 12 | 631 | 129 |
| Parochial and other Vaccinators not salaried from the Parliamentary grant, but contributing lymph at a fixed rate of payment. | 1. *Manchester* - | 1,266 | 1 | — | 188 |
| | 2–6. *Birmingham* - | 4,109 | 127 | — | 768 |
| | 7. *Liverpool* - | 1,199 | 11 | — | 71 |
| | 8. *Pimlico* - - | 346 | 13 | — | 70 |
| | 9. *Newcastle-on-Tyne.* | 563 | 104 | — | 238 |
| | 10. *Westminster* - | 616 | 6 | — | 193 |
| | 11–12. *Marylebone** | 377 | 13 | — | 10 |
| | 13. *Whitechapel** - | 819 | 1 | — | 71 |
| | 14. *Leeds* - - | 898 | — | — | — |
| | 15. Coventry - | 818 | 3 | — | 1,043 |
| | 16–17. *Glasgow* - | 1,577 | 10 | — | 481 |
| | 18. *Endell Street**- | 123 | — | — | — |
| | 19. *Sheffield* - - | 993 | 1 | — | — |
| | 20. Salford - - | 740 | — | — | 280 |
| | 21. Waterloo - | 1,126 | 45 | — | 1,350 |
| | 22. *Edinburgh* - | 474 | 4 | — | — |
| | 23. *St. Thomas's Hospital.* | 259 | 4 | — | — |
| | 24. *Glasgow West* | 647 | — | — | 4 |
| | Total - | 16,950 | 343 | — | 4,767 |
| | Grand Total | 17,556 | 355 | 631 | 4,896 |

* For six months only.

App. A. No. 4.

National Vaccine Establishment.

III.—Sources and Amount of Lymph—*continued.*

During the year, additional supplies (to the extent of 3,156 charged points and 8,263 charged tubes) were obtained from the following gentlemen:—

Mr. C. C. Claremont, Hampstead Road.
Mr. W. H. Kempster, Battersea East.
Mr. J. P. Purvis, Greenwich.
Dr. N. E. Roberts, Toxteth Park.
Dr. T. N. Orchard, Pendleton.
Dr. T. M. Johnson, Salford.
Mr. J. W. Kay, St. George's East.
Mr. J. Bark, Kirkdale.
Dr. R. S. Archer, Everton.
Dr. F. Cadell, Edinburgh.
Mr. A. Meeson, Toxteth Park.
Mr. A. Blackmore, Manchester.
Dr. R. F. Cook, Gateshead.
Dr. G. A. Miskin, Kennington.
Mr. G. W. Collins, Lamb's Conduit Street.

IV.—Distribution of Human Lymph, 1889.

Number of applications:

| | |
|---|---|
| From Medical Practitioners in England and Wales | 6,066 |
| „ „ „ Scotland | 247 |
| „ the Army | 60 |
| „ the Navy and from the Emigration Department | 57 |
| „ India and the Colonies | 131 |
| „ Diplomatic and other Foreign Services | 42 |
| Total | 6,603 |

Supplies sent out:—

| | |
|---|---|
| Charged ivory points | 3,804 |
| „ capillary tubes | 11,370 |

V.—Distribution of Calf-Lymph, 1889.

| | |
|---|---|
| Number of applications | 3,319 |
| Supplies received:— | |
| Charged ivory points | 15,001 |
| „ capillary tubes | 104 |
| Supplies sent out:— | |
| Charged ivory points | 13,991 |
| „ capillary tubes | 102 |

No. 5.





Report on the Operations of the Animal Vaccine Station at Lamb's Conduit Street during the year 1889–90; by Dr. Cory.

During the year 1st April 1889 to 31st March 1890, 285 calves were received at Lamb's Conduit Street. Of these, 281 (males 186, females 95) were vaccinated for the purposes of the station, other 4 were rejected as unfit for vaccination purposes.

The aggregate weight on reception at Lamb's Conduit Street of the 281 calves was, males 48,527 lbs., females 24,549 lbs. On dismissal from the station their weights were respectively 50,870 and 25,330 lbs., so that during retention for vaccination purposes calves of both sexes gained considerably in weight, males by an average of 12·6 lbs., females by an average of 8·2 lbs.

Of the above calves 266 were vaccinated with lymph directly derived from other calves, and 15 were vaccinated with calf lymph which had been stored. As usual, vaccinations performed with stored lymph proved much less successful than the others, 786 insertions of stored lymph producing no more than 592 vesicles, whereas 16,914 insertions in 266 calf-to-calf operations produced 15,783 vesicles; rates of insertion success respectively of 75·3 and 93·3 per cent. No material difference in the result of calf-to-calf vaccinations was observed, whether the lymph used was from calves vaccinated 96 or from calves vaccinated 120 hours previously; in both cases (104 calves in the one, 162 in the other) the rate of insertion success was practically 93·3 per cent.

*Primary Vaccinations.*—During the year 1889–90, 7,567 persons received primary vaccination at the station, five separate insertions of lymph being made in each instance. Of these persons, 3,816 were males, 3,751 females. All but 49 of the 7,567 primary vaccinations succeeded at the first attempt, and in no case was a third attempt at vaccination requisite. The amount of insertion success obtained by each of three several operators was as follows:—

Of 665 persons primarily vaccinated by Mr. Stott 13 failed to return for inspection. Of the remaining 652, 471 were on examination found to have taken in five places, 74 in four, 57 in three, 27 in two, 11 in one, and 12 were not successful on the first attempt. Mr. Stott's insertion success-rate therefore was 88·56 per cent.

Of 264 persons primarily vaccinated by Mr. G. W. Collins (acting for Mr. Stott or myself in the absence of one or other of us) 5 failed to return for inspection. Of the remaining 259, 226 were found to have taken in five places, 13 in four, 11 in three, 3 in two, 3 in one, and 2 were not successful on the first attempt. The remaining case was vaccinated (successfully) round a nævus. Mr. Collins' insertion success-rate therefore was 94·5 per cent.

Of 6,638 persons primarily vaccinated by myself, 93 who failed to return for inspection and other 17 (10 of them operated on for cure of nævi) are not taken into account in these statistics. Of the 6,528 remaining, 5,849 were found to have taken in five places, 366 in four, 137 in three, 79 in two, and 62 in one place only, while in 35 cases vaccination proved unsuccessful on first trial, an insertion success-rate of 96·02 per cent.

*Re-vaccinations.*—These during the year numbered 267. Mr. Stott performed 24, Mr. Collins 6, and I myself 237. Of these 237, 206 were successful in five places, 14 in four, 9 in three, 1 in two, and 1 was unsuccessful at first trial. Other 6 did not return for inspection. My insertion success-rate therefore in re-vaccination was 96·5 per cent.

Mr. Stott's success-rate among his 24 re-vaccinations was 88·3 per cent., and Mr. Collins' (6 cases) was 100 per cent.

In all, 62 cases returned to the station after "inspection" on account of some abnormal course of their vaccination. In the vast majority of cases the abnormality consisted of sore arm, which was almost invariably the result of ignorant treatment of the vesicles or of the scabs. For the rest there were:—9 cases of transient eruption, 2 cases of axillary abscess (both following sore arm), and a single case of erysipelas (also complicating a sore arm) which subsequently proved fatal.

All the children with sore arms rapidly recovered as soon as rational treatment was adopted. This, in many cases, consisted simply in discontinuing the application the mother had made use of.

## No. 6.

ABSTRACT of MEDICAL INSPECTIONS made in 1889 with regard to the INCIDENCE of DISEASE on particular places, and to questions concerning LOCAL SANITARY ADMINISTRATION.

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1. BEDLINGTONSHIRE (Northumberland); population (estimated), 16,000; Dr. Parsons.

   *Sanitary Authority:* Bedlingtonshire Local Board, U.*

   *Ground of Inquiry:* Mortality from "fever." — Registrar-General's Returns.

   *Chief Facts reported by Inspector:* Endemic prevalence of enteric fever in a colliery district. The bulk of this fever in 1889 referable to a case which occurred in a close, confined, and filthy part of Bedlington Town. The disease spread first to other families living in tenements under the same roof, and then in the neighbouring streets, where want of air space, privy and drain nuisances, and general want of cleanliness prevailed. In October and November there occurred also a group of cases of typhus; their cause and connexion not ascertained. Scarlet fever and measles endemic.

   Action of Sanitary Authority for the prevention of spread of infectious diseases inefficient. Information of such cases incomplete. An old building made into a hospital for infectious diseases; inconvenient in situation, faulty in plan, and with insufficient administrative arrangements; little used. Disinfecting oven of bad design and disused.

   District sewered piecemeal; sewers insufficiently ventilated; escape of drain air from untrapped inlets in neighbourhood of houses. Privies with large open middens general, in some cases very close to houses. Midden emptying ineffectually performed. Yards and back streets unpaved and in a filthy state. Over-crowded and dirty tenement houses. Good water supply.

2. BLACKBURN RURAL SANITARY DISTRICT (Lancashire); population, 8,103; Dr. Parsons.

   *Sanitary Authority:* Blackburn R.*

   *Ground of Inquiry:* Scarlet Fever.—Registrar-General's Returns, and Reports of Medical Officer of Health.

   *Chief Facts reported by Inspector:* A rural district with scattered rows of houses in neighbourhood of factories. No sewers; prevalence of sewage nuisances. House drains of defective construction and imperfectly disconnected from interior of houses. Excrement disposal partly by pail closets, partly in midden and cesspit privies, some of which are from position and construction a source of very great nuisance. Water

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* Throughout this abstract "R." denotes "Rural Sanitary Authority," and "U.", "Urban Sanitary Authority."

supply partly from Blackburn Corporation mains, partly from dipping wells, and small local reservoirs liable to contamination. Houses ill-ventilated; their surroundings often in an uncleanly condition. Urban powers not sought by Rural Sanitary Authority; no byelaws for the regulation of new buildings. Sanitary administration lax, nuisances persisting unabated though again and again reported. No effectual means of dealing with infectious diseases. Death-rate high for a rural district.

Prevalence of scarlet fever in 1887–8. Several cases of small-pox, occurring in 1888 among ragworkers at a paper mill, isolated in Blackburn Corporation Hospital. Death-rate from enteric fever high; outbreaks of that disease referable to sewage and privy nuisances, and to contamination of local water supplies.

3. Buckingham Rural Sanitary District (Bucks); population (1881), 9,833; Dr. Gresswell.

*Sanitary Authority:* Buckingham R.

*Ground of Inquiry:* General sanitary condition of district.—Reports of Medical Officer of Health.

*Chief Facts reported by Inspector:* District agricultural. The villages and hamlets situated on Drift, Oxford Clay, or Great Oolite. Four-fifths of the dwellings are cottages; about two-thirds rated under 5*l*. Dwellings generally deficient in ventilation and unclean, and a large number dilapidated.

Out-door premises commonly unwholesome owing to accumulations of house refuse, drainage defects, and sewer-ditches; piggeries and over-flowing privy-vaults often near to houses. Scavenging left to occupiers, and neglected. Water chiefly from numerous shallow wells on the premises; the rest (perhaps one-twelfth) conducted in pipes from wells at a distance; much of it liable to pollution. Part of house drainage enters highway drains, which during late years have been largely reconstructed to serve as sewers. Recently some improvement of cottages, privies, and water-supply, but general sanitary administration much neglected (six hours only per year devoted by Sanitary Authority to sanitary business). No byelaws. No infectious hospital. Enteric fever endemic.

4. Camberley and York Town (Surrey); population (estimated), 4,000; Dr. Parsons.

*Sanitary Authority:* Farnham R. (Frimley Parochial Committee).

*Ground of Inquiry:* Diphtheria.—Request of Rural Sanitary Authority.

*Chief Facts reported by Inspector:* Outbreak of diphtheria in 1888, occurring somewhat suddenly (10 families invaded in first fortnight) in households somewhat widely scattered in the two places. Cause of outbreak obscure. No community of school attendance, milk supply, or water supply among persons first attacked. Subsequent spread of disease by personal intercommunication. Dirty, unrepaired streets. Water supply from shallow wells, inferior in quality and insufficient for proper drain flushing. No isolation hospital.

5. Chester ; population (1881), 36,794; Dr. Ballard.

*Sanitary Authority :* Chester Town Council, U.

*Ground of Inquiry :* Prevalence of enteric fever.—Report of Medical Officer of Health.

*Chief Facts reported by Inspector :* Large prevalence of enteric fever in a city which has been prone to epidemics of the disease, and which has, not a few, faults in its sewerage and methods of disposing of excrement and refuse. The most extensive danger to the city, however, consists in its public water-supply. It is drawn from the upper waters of the Dee, which at spring tides are polluted with sewage.

6. Cowpen (Northumberland) ; population (1881), 10,003 ; Dr. Parsons.

*Sanitary Authority :* Cowpen Local Board, U.

*Ground of Inquiry :* "Fever."—Registrar-General's Returns.

*Chief Facts reported by Inspector :* District comprises an East Ward containing Cowpen Quay and Waterloo, a compact maritime town ; and a West Ward containing several detached colliery villages.

High general and infant mortality in the district. "Fever," principally enteric, more or less prevalent every year ; outbreaks in particular years ascribed to pollution of public water service, the escape of foul air from defective and unventilated sewers, and the foul condition of the Slake,—a tidal creek into which the sewers empty. Enteric fever in 1889, chiefly prevalent in West Ward at Bebside, a colliery village in bad sanitary condition, unprovided with proper sewers or water supply, water being very scarce and obtained from objectionable sources.

In East Ward many improvements have been made of late years, but objectionable open privy-middens are still in vogue, and sewers are insufficiently ventilated and flushed. Public water-supply insufficient, and in need of better filtration ; exposed, both before and after filtration, to risk of contamination. No isolation hospital, disinfecting apparatus, or mortuary.

7. Cradley (Worcester) ; population (1881), 5,284 ; Dr. Gresswell.

*Sanitary Authority :* Stourbridge R.

*Grounds of Inquiry :* (*a.*) Enteric fever.—Registrar-General's Returns. (*b.*) To ascertain sanitary action taken since previous inspections in 1880 and 1886.

*Chief Facts reported by Inspector :* Semi-urban. Inhabitants engaged in mining, and (females as well as males) in chain-making. Sanitary administration greatly neglected. Very little improvement effected since previous inspections. Large proportion of the cottages insufficiently ventilated and unclean. Premises filthy owing to general want of proper drainage, and to foul middens. House-drainage often finds its way to highway drains (non-cemented pipes and old culverts) which

discharge into the River Stour. Old-fashioned and foul middens, situated frequently close to cottages, scavenged only at intervals of six months. Water for about half the dwellings from the South Staffordshire Waterworks Company's service; the other half getting supply from dangerous sources. Slaughter-houses and dairies badly constructed and badly managed.

Enteric fever outbreak affecting 52 dwellings between December 1887 and June 1889: 113 cases and 16 deaths. Extension of the fever referable chiefly to specifically polluted water. No isolation hospital. (*See* p. 51 of present volume.*)

8. Darton Registration Sub-District (Yorks, W.R.); population (1881), 7,078; Dr. Bruce Low.

*Sanitary Authorities:* Darton U. and Barnsley R.

*Ground of Inquiry:* Heavy mortality from "croup."—Report of Medical Officer of Health for 1888.

*Chief Facts reported by Inspector: Darton U.*—Prevalence of throat illness, much of it diphtheria, throughout the district during 1888.

Drainage imperfect. Privies and ashpits improperly constructed. Scavenging inefficient. No byelaws in force. Slaughter-houses and dairies and cowsheds not registered or regulated. Absence of isolation hospital provision. No means for proper disinfection of clothing and bedding.

*Wooley Colliery Village, Barnsley R.*—Prevalence of sore-throat and diphtheria throughout the village during the later months of 1888. Ashpits and privies on a higher level than cottages, and refuse sometimes washed into latter when heavy rains prevailed, creating nuisance. Water from reservoir upon the hill turbid at times.

9. East Haddon (Northamptonshire); population (1881), 752; Dr. Bruce Low.

*Sanitary Authority:* Brixworth R.

*Ground of Inquiry:* Sudden outburst of fatal diphtheria.—Local request for inspection.

*Chief Facts reported by Inspector:* Diphtheria endemic in the district for some years. Mild cases of throat illness at East Haddon in June 1889, mostly in children attending school where personal contact seems to have spread diphtheria. Further spread assisted by a school treat in the village whereat were gathered together sick and healthy. Unwholesome conditions common in East Haddon. Local wells polluted or liable to pollution; defective drainage; nuisances from pit privies, pig-styes, and from accumulations of house refuse and manure. Some overcrowding; insufficient ventilation of cottages. General want of sanitary supervision by the local authority. No isolation hospital provided.

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* Report reprinted as App. A. No. 7, of present volume.

10. Faringdon Rural Sanitary District (Berks); population (1881), 13,676; Mr. Spear.

*Sanitary Authority:* Faringdon R.

*Grounds of Inquiry:* (*a.*) High mortality from scarlatina.—Registrar-General's Returns.—(*b.*) Necessity of further information as to arrangements for the discharge of the duties of Medical Officer of Health.

*Chief Facts reported by Inspector:* Very severe outbreak of scarlatina in Faringdon Town; 38 per cent. of cases fatal. Outbreak preceded by epidemic measles, and conditions under which sufferers lived generally unfavourable to health. No adequate precautions taken by the authority for first three months of scarlatina spread. Water supply liable to pollution and often inadequate in quantity. Many defects of sewers and drains. Ill-flushed pan-closets in general use. Accumulations of house refuse about dwellings. Houses small, ill-ventilated, and often overcrowded. People receiving very low wages.

In the other villages of the district:—No regular means of drainage. Slop water passing by various channels to the nearest stream and thence to the Thames. Large and deep privy pits in use both for cottages and village schools. Water derived from shallow wells and springs imperfectly protected against pollution, and occasionally from streams receiving sewage. Many houses unfit for habitation; some overcrowding.

The four Poor Law Medical Officers appointed Medical Officers of Health for their respective districts, receiving each a salary of 10*l.* With one exception their reports presented in the last three years give no indication of the sanitary condition of the district. (*See* p. 83 of present volume.*)

11. Grays Registration Sub-District (Essex); population (estimated), 15,350; Dr. Airy.

*Sanitary Authorities:* Orsett R. and Grays Thurrock U.

*Ground of Inquiry:* Diphtheria.—Registrar-General's Returns.

*Chief Facts reported by Inspector: Orsett R.*—Outbreak of diphtheria at "Whitehall Cottages," adjoining Grays Thurrock, among members of a party who had been "hopping" in Kent. Subsequent extension to neighbours by personal communication. Later appearance of the disease at East Tilbury. Nuisances from foul cesspools. Outbreak of scarlatina at East Tilbury, traceable to personal communication.

*Grays Thurrock U.*—Participation in outbreak of diphtheria above referred to. Prevalence of enteric fever. Want of drainage: nuisances from overflowing cesspools and foul privies. Want of means of isolation.

12. Halstead Registration District (Essex); population (1881), 17,004; Dr. Bruce Low.

*Sanitary Authorities:* Halstead R. and U.

*Ground of Inquiry:* Prevalence of diphtheria.—Registrar-General's Returns.

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* Report reprinted as App. A., No. 11 of present volume.

*Chief Facts reported by Inspector: Halstead R.*—Endemic sore-throat related to continued prevalence of diphtheria. Increase of diphtheria deaths during last five years, along with increase of deaths registered as from other throat affections. Cases of diphtheria in certain localities associated with croup, laryngitis, and tracheitis,—maladies not recognised as related to diphtheria. Mild cases and convalescents allowed to mix with healthy persons at school and elsewhere. This the chief factor apparently in diffusing the disease. Insanitary villages not exceptionally liable to diphtheria.

*Halstead U.*—Persistence of diphtheria in greater or less amount in the town for the last 15 years. Increase in the number of deaths from diphtheria and allied throat disease during the last five years. Diffusion of diphtheria promoted chiefly by personal communications, and during the outbreak in 1888, especially by school influence. Persistence of the disease in the urban district, related to prevalence of same ailment in the surrounding rural district. (*See* p. 73 of present volume.*)

13. Hanley Urban Sanitary District (Staffordshire); population (estimated), 56,000; Mr. Spear.

*Sanitary Authority:* Hanley Town Council, U.

*Ground of Inquiry:* Excessive fatality from measles.—Registrar-General's Returns.

*Chief facts reported by Inspector:* Epidemic of measles in the Potteries and neighbouring parts of North Staffordshire, affecting in succession Cheadle, Longton, Stoke, Tunstall, Fenton, Burslem, Hanley, and Newcastle-under-Lyme. High fatality of the disease in Hanley, its incidence almost exclusively on children. Schools in their relation to the epidemic. (*See* p. 115 of this volume.†)

14. Hatfield Rural Sanitary District (Herts); population (1881), 6,502; Dr. Bruce Low.

*Sanitary Authority:* Hatfield R.

*Ground of Inquiry:* General sanitary condition of Hatfield.—Reports of Medical Officer of Health.

*Chief facts reported by Inspector:* Defects of the Hatfield main sewer in London Road, and want generally of proper ventilation of sewers. Imperfect house drainage in some parts of the Old Town. Inadequate and improperly constructed closet accommodation; flushing arrangements imperfect in many instances. Slaughter-houses in unsuitable positions; not regulated and with defects of construction. Stables in confined spaces close to dwellings. At New Town grave defects in sewage outfall and in condition of closets. Wells liable to contamination.

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* Report reprinted as Appendix A. No. 9, of present volume.
† Report reprinted as Appendix A. No. 13, of present volume.

15. Hoo Rural Sanitary District (Kent); population (estimated), 3,280; Mr. Spear.

*Sanitary Authority:* Hoo R.

*Ground of Inquiry:* Absence of any evidence of sanitary progress in reports of the Medical Officer of Health.

*Chief Facts reported by Inspector:* District comprises several scattered villages; agriculture and brickmaking the almost exclusive industries. District inspected by Dr. Airy in 1881, and by Dr. De Chaumont in 1885. With exception of provision of a better water-supply to one village, no improvement effected since the earlier date; certain attempts at improvement of drainage and privy accommodation ill-considered and even harmful. Nuisances from improper disposal of liquid and solid filth almost universal; water-supplies frequently polluted and insufficient. The dwellings generally of an inferior class; many unfit for human habitation. No provision for dealing with infectious disease. The Inspector of Nuisances not placed in proper relation to the Medical Officer of Health; the recommendations of the latter officer ignored by the Local Authority.

16. Horwich Registration Sub-District (Lancashire); population (estimated), 23,200; Mr. Spear.

*Sanitary Authorities:* Horwich U., Westhoughton U., and Bolton R. (part of area).

*Ground of Inquiry:* High mortality from diphtheria and "croup."—Registrar-General's Return.

*Chief Facts reported by Inspector:* In the Registration Sub-district there were registered during the $2\frac{1}{4}$ years ending March 31st, 1889, 38 deaths from "croup," "tracheitis," and "laryngitis," and six from diphtheria. As regards certain of the 38 deaths, the circumstances indicated that the disease was really diphtheria; a few others were apparently associated with the infection of scarlatina, and a few others again with that of measles. (*See* p. 79 of present volume.*)

(*a.*) *Horwich U.* (population of district, estimated (1888), 12,000).—The town of Horwich of extraordinarily rapid growth, sanitary organisation and supervision not keeping pace therewith. Streets unmade; sewage ponding on surfaces; excrement accumulated about the dwellings; building byelaws habitually infringed. The town has public water-supply; outlying localities supplied by local wells and springs of doubtful purity; dairies, cow-sheds, and slaughter-houses insufficiently regulated and a source of nuisance. The sanitary officers underpaid; no isolation hospital, and no disinfecting chamber. Early information of the appearance of infectious disease not secured.

(*b.*) *Westhoughton U.* (population of district, estimated (1888), 10,400).—Town in chief part sewered. Sewers ventilated, and sewage disposed of on land. House drains un-

* Report in part reprinted as Appendix A. No. 10, of present volume.

ventilated; gullies often dilapidated. Bye streets unmade. Large privy-middens in general use; no public provision for the emptying of these receptacles. Some of the houses damp and ill-ventilated. Water from the mains of the Bolton Corporation, except for out-lying farmhouses, where supplies are often liable to pollution. Slaughter-houses, cow-sheds, and dairies insufficiently regulated; the former a source of considerable nuisance. No isolation hospital or disinfecting apparatus.

(*c.*) *Bolton R.* (*part of*) (Lostock parish; population, 800).—Population scattered. Houses mostly supplied with water from the Bolton Corporation mains. Privy middens of objectionable type; drains often dilapidated; yards unpaved and sloppy. Less sanitary work effected at Lostock than in other parts of the rural district.

17. Houghton-le-Spring Rural Sanitary District, Northern Division (co. Durham); population (1881), 17,390; Dr. Page.

*Sanitary Authority:* Houghton-le-Spring R.

*Ground of Inquiry:* Outbreak of enteric fever.—Reports of Medical Officer of Health.

*Chief facts reported by Inspector:* Sudden outbreak of enteric fever, upwards of 300 cases with 29 deaths occurring between April and June 1889. Fever limited to particular villages and groups of dwellings within the area of supply of the New Herrington water service. Immunity of the neighbouring town of Houghton-le-Spring and villages dependent upon different service, and upon local springs and wells.

Contamination of the particular water service by sewage matter from a farmhouse three-quarters of a mile distant. Sewage there got rid of down a fissure in the Magnesian Limestone which was found to be in direct communication with the pumping-well at the waterworks. (*See* p. 61 of present volume.*)

18. Leek Rural Sanitary District (Staffordshire); population (1881), 13,760; Dr. Parsons.

*Sanitary Authority:* Leek R.

*Ground of Inquiry:* Diphtheria.—Registrar-General's Returns and reports of Medical Officer of Health.

*Chief Facts reported by Inspector:* Several apparently unconnected outbreaks of diphtheria in separate localities, limited to a small number of households, which suffered severely.

Inmates of all the households invaded exposed to grave unsanitary conditions; defective drains, badly placed privies, damp houses, contaminated water-supply, and the like. No connexion of the diphtheria with milk supplies or diseases of animals. Most of the initial cases had been exposed to the infection of scarlet fever. Spread of the malady by personal infection. Some cases had a red rash. Action of Rural Sanitary Authority defective as regards obtaining early information of infectous diseases, making provision for their isolation, and rectifying unsanitary conditions of houses.

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* Report reprinted as Appendix A. No. 8, of present volume.

19. Longton Urban Sanitary District (Staffordshire); population (estimated), 35,000 ; Mr. Spear.

*Sanitary Authority :* Longton U.

*Ground of Inquiry :* Registrar-General's Returns.—Excessive mortality from enteric fever.

*Chief Facts reported by Inspector :* Enteric fever: 66 household invasions, 155 attacks, and 29 deaths during 1888 and first five months of 1889. Sewerage, food-supply, milk, &c., apparently affording no explanation of disease extension. Dissemination of the disease by means of specifically infected cesspit privies. But special incidence of primary invasions on part of the town getting supply from a particular section of the public water service.

20. Maesteg Urban Sanitary District; population (estimated), 9,000; Mr. Spear.

*Sanitary Authority :* Maesteg U.

*Ground of Inquiry :* Insufficient information as to action taken and contemplated by the Authority in view of the inquiry instituted by the Board in 1888.

*Chief Facts reported by Inspector:* Improvements hitherto effected but trifling :—a few new drains ; a little (very inadequate) improvement in water-supply ; a few privy cesspits abolished; and some repairs to a small portion of the cottage property.

So-called cottage hospital remains quite unfit for its purpose and could not in its present condition be safely used.

The Sanitary Authority undertakes :—

1. That the water-supply of the district shall be improved speedily.
2. That measures shall be taken for improving the dwellings of the poor.

Upon the questions of the systematic sewering of the district, of the appointment, jointly with neighbouring districts, of a Medical Officer of Health, and of the provision of proper hospital accommodation, a satisfactory decision not yet arrived at by the Sanitary Authority.

21. Penistone Registration Sub-District (Yorks, W.R.) ; population (estimated), 8,900 ; Mr. Spear.

*Sanitary Authorities:* Gunthwaite and Ingbirchworth U., Hoylandswaine U., Penistone U., Stocksbridge U. (part of area), Thurlstone U., and Penistone R. (part of area).

*Ground of Inquiry :* Fatality from diphtheria.—Registrar-General's Returns.

*Chief Facts reported by Inspector :*

(*a.*) *Gunthwaite and Ingbirchworth U.* Population of district (400) mainly in the village of Ingbirchworth. A part only of this village sewered; method of disposal of the sewage cause of nuisance. Water-supplies (from dip wells, &c.) liable to pollution and insufficient. Attempt at improvement of the privy accommodation of the district not successful

owing to want of provision for refuse removal. Several houses damp and ill-ventilated.

(*b.*) *Hoylandswaine U.* (population of district 800).—A scattered village, with many cottages decayed, damp, ill-ventilated, and dirty; some overcrowded. The sewers of rough stone-work, and half choked with filth; the drains dilapidated, and occasionally directly connected with the interior of houses. Dilapidated privy-middens in general use; no provision for refuse removal. The water-supply generally from dip-troughs fed from garden and manured ground; two standpipes from the Barnsley mains serve a part only of the village. Dairies not registered. Medical Officer of Health and Inspector of Nuisances not efficient.

(*c.*) *Penistone U.* (population of district, 2,500).—Between August 1888 and March 1889, 37 households invaded by diphtheria (84 persons attacked); disease, in the almost entire absence of precautions, spreading to near neighbours and visitors.

Sewer system incomplete; sewers imperfectly ventilated; sewage not so disposed of as to avoid nuisance. Private drains ill-constructed and often dilapidated. Excrement stored in leaky privy-middens. No public provision for refuse removal. Many cottages damp, ill-ventilated, and some overcrowded. Water-supply generally from the waterworks of the Authority. Private streets unmade and neglected; yards unpaved and sloppy. Slaughter-houses, cowsheds, &c., unregulated and a source of nuisance. Medical Officer of Health (salary of 13*l.* per annum) and Inspector of Nuisances not efficient.

(*d.*) *Stocksbridge U.* (population of district, 6,000, of which 1,000 within Penistone Registration Sub-district).—A small localized outbreak of diphtheria, in June 1888, amongst neighbours and schoolfellows.

Useful sanitary work of late accomplished. Sewers and drainage of houses improved; public water-supply extended; small wooden isolation hospital provided, and system of notification of infectious disease set on foot. Dairies registered and regulated.

(*e.*) *Thurlstone U.* (population of district, 3,000).—Diphtheria invaded 20 households (37 persons attacked) between June 1888 and March 1889 in and about the central village (Thurlstone) of the district. Disease spread—apparently by personal contagion—amongst friends, schoolfellows, &c. No provision for isolation.

District only partially sewered; sewers often roughly constructed and unventilated. Sewage discharged into the River Don or its tributaries. Privy nuisances prevalent; no public provision for refuse removal. Many of the houses damp, ill-ventilated, and dilapidated; some overcrowded. Water from local wells and springs inadequate in amount and often liable to contamination. Dairies, cowsheds, &c., neither registered nor regulated.

(*f.*) *Penistone, R. (part of); population estimated at* 1,200. Outbreak of enteric fever at village of Oxspring March to June 1888 referable to a particular local water

supply which was found to be liable to contamination from house and farmyard drainage, and from manured fields.

Nuisances from defective means of excrement and refuse removal common. Many cottages damp and ill-ventilated. Dairies and cowsheds not sufficiently regulated.

22. Pontypridd Registration Sub-district (Glamorganshire); population (estimated), 39,700; Mr. Spear.

*Sanitary Authorities:* Pontypridd U. and R.; Mountain Ash U.; and Ystradyfodwg U.

*Ground of Inquiry:* Prevalence of diphtheria.—Registrar-General's Returns.

*Chief Facts reported by Inspector:* (*a.*) *Pontypridd R.*—Epidemic prevalence of diphtheria in the new mining village of Cilfynydd. Disease spread by personal contagion. Sewage and excrement nuisances prevalent; considerable overcrowding. No measures taken for controlling spread of the disease.

Several other villages in the rural district in an unsatisfactory condition as regards water-supply, sewerage, means of excrement disposal, and house accommodation.

(*b.*) *Pontypridd U.*—Cases of "croup" and of severe sore-throat. Much contamination of soil and air from defective rubble-sewers and drains, dilapidated yards, and foul cesspits. Many houses unfit for habitation from dampness, want of proper ventilation, &c. Slaughter-houses, dairies, and common lodging-houses not properly regulated. No public provision for isolation of infectious disease.

(*c.*) *Ystradyfodwg U.*—A main sewerage scheme (in conjunction with the Pontypridd Urban Authority) in process of being carried out; improvement effected of late years in street sewers. Some improvement also in means of refuse disposal. Accommodation of lodgers in cottage houses, not under proper regulation; water-supply insufficient. A small isolation hospital recently provided.

(*d.*) *Mountain Ash U.*—A few deaths from "croup"; no recognised diphtheria. Public water-supply (of late improved) in general use. District, except one outlying village, sewered. Accommodation of lodgers in small and poorly-ventilated cottages. not under proper regulations. An isolation hospital about to be provided.

23. Rhayader Rural Sanitary District (Co. Radnor); population (1881), 6,741; Mr. Spear.

*Sanitary Authority:* Rhayader R.

*Ground of Inquiry:* Continued complaints of the insufficiency of water-supply in the village of Newbridge, and at Llandrindod Wells, a health resort.—Request for advice on the part of the Sanitary Authority.

*Chief Facts reported by Inspector: Newbridge, population*, 340—Numerous cases of scarlatina, measles, diarrhœa, and diphtheria during recent years. A serious outbreak of enteric fever in 1878 traced to specific pollution of a spring that is still resorted to.

A single stand-pipe, supplied with water fairly free from risk of pollution, serves for about one-half the houses of the village. The remainder, 200 to 800 yards from this stand-pipe, depend on supplies liable to dangerous contamination.

*Llandrindod Wells* (largely resorted to by visitors during the summer).—Water-supply in the hands of a Company unable or unwilling to satisfy legitimate requirements of the inhabitants. Many houses in the area over which the Company have Parliamentary powers as yet unsupplied with this water. In times of dry weather service intermittent ; pressure in mains habitually insufficient to carry water to the upper water-closet cisterns of the more elevated houses; amount available for the flushing of the public sewers inadequate in summer. The Company taking steps to supplement their supply from a stream of very doubtful purity.

24. Rochester Urban Sanitary District (Kent) ; population (estimated), 23,000 ; Mr. Spear.

*Sanitary Authority :* Rochester U.

*Grounds of Inquiry :* Local information and complaint of prevalence of enteric fever, scarlatina, and diphtheritic sore-throat at Borstal, within the district. Absence of evidence of sanitary activity.

*Chief Facts reported by Inspector :* Entire absence in Rochester of any systematic sewerage. Solid and liquid sewage disposed of in deep and large cesspits sunk into the chalk and from which it is intended that the liquid part of the sewage shall soak into the soil. Cesspools that rapidly fill (as in low-lying alluvial localities) provided with overflow pipes to the nearest highway drains or other channels. Deep privy-pits in general use; otherwise water-closets discharging into the cesspits. Drains in the older property unventilated. The emptying of cesspools and removal of refuse undertaken, June 1888, by the Authority under Order of the Local Government Board. Little or no sanitary advantage obtained ; cesspools emptied, as before, only when full and overflowing.

House accommodation in older parts of town very unsatisfactory. Many courts close and confined ; dwellings exceedingly small and ill-ventilated, some overcrowded and dirty. Little or no effort yet made to deal with crowded areas or with houses unfit for habitation.

Public water-supply from deep wells in the chalk outside town limits. In some quarters danger of pollution of this water during its distribution owing to direct pipe communication between the mains and water-closet pans. About 135 local wells, many liable to pollution from cesspool soakage, still in use. The Authority possess, in conjunction with the Chatham Urban Sanitary Authority, a hospital for infectious disease and a disinfecting chamber. (*See* p. 131 of the present volume.*)

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* Report reprinted as Appendix A. No. 14., of present volume.

25. Rye Rural Sanitary District (Sussex); population (estimated), 8,374; Mr. Spear.

*Sanitary Authority:* Rye R.

*Ground of Inquiry:* Outbreak of diphtheria.—Local complaints.

*Chief Facts reported by Inspector:* In 1888, seven deaths from diphtheria and three from croup registered in the rural district. In October 1889 a localized outbreak of diphtheria, with three deaths, at Winchelsea village where cases of follicular tonsillitis had been previously not uncommon.

The diphtheria affected houses exposed to foul effluvia from large accumulations of excrement and other refuse, in localities where the ground was sodden with sewage. The water-supplies of several of the infected villages deficient in quantity and exposed to sewage pollution. The cottages of the district occasionally damp, ill-ventilated, and overcrowded. Nuisances from ill-kept slaughter-houses and pig-pounds.

No proper supervision of the district by the several Medical Officers of Health; action of the Inspector of Nuisances partial and ill-directed. Remuneration of these Officers inadequate.

26. St. George, Hanover Square, Parish (population (1881), 149,748); and adjoining localities. Dr. Barry.

*Sanitary Authorities:* Vestries of the Parishes of St. George, Hanover Square, Kensington, and Chelsea.

*Ground of Inquiry:* Sudden and localized outbreak of enteric fever.

*Chief Facts reported by Inspector:* Necessary information about the fever not to be had; families amongst which cases of fever had occurred having removed to the country at the close of the London season.

Prevalence of enteric fever referable to temporary admixture of infected milk with usual supply. Nuisances from sewer ventilators due to deficient flushing after drought; accumulations of manure and refuse in mews.

27. Samford Rural Sanitary District (Suffolk); population (1881), 11,564; Dr. Airy.

*Sanitary Authority:* Samford R.

*Ground of Inquiry:* Diphtheria.—Registrar-General's Returns.

*Chief Facts reported by Inspector:* Severe prevalence of diphtheria, June—November 1889. Outbreak related in point of time to debarkation in the locality of its occurrence of foul smelling London manure. Extension of the disease by personal intercourse in particular instances. Nuisances from foul privies. Some wells polluted.

28. Skelmanthorpe (Yorks, W.R.); population (1881), 3,120; Dr. Bruce Low.

*Sanitary Authority:* Skelmanthorpe Local Board, U.

*Ground of Inquiry:* To ascertain action taken in sanitary matters since previous inspection by Dr. Gresswell in 1886.

*Chief Facts reported by Inspector:* No distinct improvement of district since date of inspection by Dr. Gresswell. Scavenging

arrangements very defective. Privies and ash-pits improperly situated and imperfectly constructed. Byelaws as to cleansing of privies and ash-pits, regulation of new buildings, and regulation of common lodging-houses and of slaughter-houses, not enforced. No provision made for isolation of infectious disease, and no means for proper disinfection of clothing and bedding.

29. Sowerby Bridge (Yorkshire); population (1881), 8,724; Dr. Parsons.

*Sanitary Authority:* Sowerby Bridge Local Board, U.

*Ground of Inquiry:* Diphtheria.—Registrar-General's Returns. —Report of Medical Officer of Health.

*Chief Facts reported by Inspector:* Outbreak of diphtheria commencing in October or November 1888, and persisting up to date of inspection in May 1889. Origin not ascertained. Earliest cases among children attending the Board Schools, at which offensive trough closets had existed. Later, the disease spread by personal communication at school and elsewhere.

Sowerby Bridge, a manufacturing town, built on the steep slopes of a valley: houses mostly back-to-back or one above another in tiers, without yard space. Sewers and drains insufficiently ventilated: drain inlets as a rule inside the houses, in some cases inefficiently trapped; newer houses have w.c.'s, often underground, and ill-ventilated; older houses furnished with midden-privies, frequently in confined situations, and too near to the dwellings. Byelaws obsolete. No disinfecting apparatus. Arrangement with Halifax Corporation for use of isolation hospital, availed of only in the case of small-pox.

30. Thirsk Rural Sanitary District (Yorks., N.R.); population (1881), 12,848; Dr. Parsons.

*Sanitary Authority:* Thirsk R.

*Ground of Inquiry:* Enteric fever.—Registrar-General's Returns. —Reports of Medical Officer of Health.

*Chief Facts reported by Inspector:* Enteric fever mostly in Thirsk and Sowerby, associated with privy nuisances, defective drains, and water-supplies from wells exposed to risk of pollution.

Sewers unventilated and partly without means of flushing. Drains of defective construction, inlets badly trapped. Privies with wet offensive leaky ashpits. Water-supply chiefly from shallow wells. A public supply, furnished by a Company, little used. Narrow ill-paved yards. Houses ill-ventilated. Abatement of nuisances neglected. Byelaws disregarded.

31. Tredegar Urban Sanitary District (Brecknock); population (estimated), 18,100; Mr. Spear.

*Sanitary Authority:* Tredegar U.

*Ground of Inquiry:* Continued prevalence of diphtheria.— Reports of Medical Officer of Health.

*Chief Facts reported by Inspector:* Until 1884 district practically free from diphtheria for many years. A small localised outbreak in that and another in the following year. In 1886

(October) an epidemic outburst of diphtheria; subsequently, persistence of the disease, with recurring epidemic outbreaks, until the end of 1889. In the last of these, schools instrumental in widely disseminating the infection. Diphtheria thus imported to localities where air and soil were polluted by sewage, maintained itself and spread, whereas in other and more wholesome localities it failed to do so to any conspicuous extent.

32. Upton (population (1881), 185) and Macclesfield (population (1881), 37,514) (Cheshire); Dr. Parsons.

*Sanitary Authorities:* Macclesfield R. and Macclesfield Town Council, U.

*Ground of Inquiry:* Scarlet fever.—Request of Macclesfield Rural Sanitary Authority and of inhabitants of Upton.

*Chief Facts reported by Inspector:* An outbreak of scarlet fever and of sore-throat (some of it diphtheritic, and in two instances designated diphtheria) in Upton and neighbouring part of borough of Macclesfield. Outbreak began suddenly, January 24th or 25th, 1889, and was practically confined to the customers of a particular dairy. The incidence of disease upon households was greater the larger the amount of the milk consumed per head. The more severe cases mostly among large milk drinkers.

The mode in which the milk received infection obscure: no human source discoverable, and the cows pronounced healthy by veterinary authorities. The outbreak had coincided in point of time with distribution of the milk of a recently purchased and newly-calved cow, which had drunk water from a sewage-polluted well. (*See* p. 89 of present volume.*)

33. Uxbridge Urban Sanitary District (Middlesex); population (1881), 7,669; Dr. Bruce Low.

*Sanitary Authority:* Uxbridge U.

*Ground of Inquiry:* Diphtheria prevalence.—Request of Sanitary Authority.

*Chief Facts reported by Inspector:* Diphtheria imported into Urban Sanitary District from adjoining Rural District towards end of 1888. Occurrence of mild cases during spring and summer months of 1889. Gradual increase in severity of cases. Disease especially fatal in August, September, and October. Diffusion of the diphtheria mainly through agency of schools. Evidence of pollution of the water-supply from leakage into Local Board's well; no connexion traceable between water service and diphtheria prevalence.

34. Wellingborough Rural Sanitary District (Northamptonshire); population (estimated), 24,760; Mr. Spear.

*Sanitary Authority:* Wellingborough R.

*Ground of Inquiry:* Enteric fever.—Registrar-General's Returns. Need for further information as to sanitary administration.

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* Report reprinted as App. A. No. 12 of present volume.

*Chief Facts reported by Inspector:* Much of the work of sanitary administration left to parochial committees. These on the whole have done good service; but defects of sewerage, water-supply, and the like often undealt with until some outbreak of enteric fever has called prominent attention to them. This the case recently at Irthlingborough and at Irchester villages.

In many of the villages of the district rough stone channels used as sewers, are allowed to discharge into open streams. Water-supplies almost universally from local wells and "springs," which, the soil being porous, are greatly liable to contamination. Pail closets largely introduced in substitution of the old privy-midden, and with great success. The Authority provide for the scavenging of the populous places. Building byelaws in force in Rushden (the largest village), are fairly administered; in other growing localities they are much required. The urban powers obtained by the Authority for the paving of streets, &c., in Rushden need to be enforced. No public provision for the isolation of infectious disease.

35. Windsor, New (Berkshire); population in 1881, 12,273; Dr. Airy and Mr. Arnold Taylor.

*Sanitary Authority:* New Windsor Town Council, U.

*Ground of Inquiry:* To ascertain action of Town Council, since Inspectors' visit in 1886.

*Chief Facts reported by Inspectors:* New byelaws in force; Inspector of Nuisances appointed and actively at work; some improvement in courts and lanes. The unwholesome crowding of dwellings upon area still remaining and to a serious extent, but prospect of amendment in this respect. No provision for isolation of cases of infectious disease, or for disinfecting infected articles. Refuse destructor still wanting.

36. Worcester; population (estimated), 43,000; Dr. Parsons.

*Sanitary Authority:* Worcester Town Council, U.

*Ground of Inquiry:* Proposals contained in byelaws submitted by the Town Council for the Board's approval in reference to arrangements for removal of excrement and house refuse.

*Chief Facts reported by Inspector:* Ashes and house refuse for most part stored in movable receptacles and collected once a week by the Corporation free of cost; partly accumulated also in large deep ashpits (sometimes in connexion with privies, sometimes not so), for the emptying of which a charge is made by the Corporation.

Excrement disposal chiefly by waterclosets, but nearly 300 midden privies remain; these, however, in process of being converted into waterclosets.

## No. 7.



Report on the Sanitary Condition of Cradley in the Rural Sanitary District of Stourbridge, and on Enteric Fever there; by Dr. Gresswell.

Cradley,—a parish under the jurisdiction of the Stourbridge Rural Sanitary Authority,—like many neighbouring places in the coal and iron districts of Worcestershire and Staffordshire, has long been known to the Board for grave sanitary shortcomings and for prevalence of filth diseases. And a severe outbreak of enteric fever having occurred in Cradley in the latter part of 1888 and the early part of 1889, an inspection of the district was ordered with a view of learning the circumstances which had attended this disease-prevalence, and the nature and extent of the improvements effected by the Sanitary Authority in regard of the recommendations of the Board, addressed to the Authority after three several inspections, the first by Dr. Ballard in 1873, the second by Dr. Parsons in 1880, and the third by myself in 1886.

Cradley parish, in North Worcestershire, occupies 732 acres within a semicircular bend of the River Stour. It is separated by the latter from Hawn, Cradley Heath, and Quarry Bank, while to the west and south it adjoins the Lye, Wollescote, Lutley, and Hasbury.

The portion of the river which bounds Cradley flows north-eastwards, then north-westwards, and finally south-westwards; and in its course falls from a level of 330 feet to one of 250 feet above Ordnance datum. Cradley lies at an average elevation of some 400 feet above the same datum.

The inhabitants of Cradley, 5,284 in number at the census of 1881, occupy for the most part the summit and slopes of a straggling ridge, which, speaking generally, takes the same direction as the river, and which, from an elevation of about 500 feet above Ordnance datum at Parkside in the south, descends in a course of 2 miles or so to a level of about 300 feet at Lane's End in the north-west. The main line of dwellings is, however, not continuous; broadly speaking, there are two groups of population, of which the northern is much the larger. The dwellings of the southern group are situated for the most part on or towards the summit of the ridge, those of the northern are situated chiefly on the sharp slope from the ridge to the river, where they form

a small compact town reaching from near the summit of the ridge down to the river's edge, with one main street (the High Street, continued on as Lyde Green) and smaller streets and lanes at right angles thereto, together with some courts. Hereafter it will be convenient to speak of the northern group of dwellings as Cradley proper. The lower part of this group, perhaps a third of it, is built upon clay of varying thickness; most of the dwellings of the rest of the district stand upon sandstone or on the rubble and sand, into which it has been converted towards the surface; while beneath the whole of the district are the Coal Measures. Here it is to be remarked that mining operations have brought about subsidences in various parts of the district, so that not a few buildings, including the church, have been much damaged.

The rateable value of Cradley parish is 16,550*l.*, but more than half of this sum is derived from other than house-property, chiefly from coal- and fireclay-mines and fire-brick works. House-property, for the most part freehold and in the hands of some 250 owners, has a rateable value of only 7,479*l.*, as many as 612 out of the total of 1,102 houses being rated at values of or below 5*l.*, and only 155 at values of or above 10*l.* It is believed that much of the house property is mortgaged.

The inhabitants are engaged in mining, and, females as well as males, in chain-making in small forge-shops near to the cottages. They have increased in numbers very steadily for many years past, the successive census returns commencing with 1831 having been as follows, viz., 2,202, 2,686, 3,383, 4,075, 4,700, and 5,284.

Passing now to the general sanitary condition of Cradley, and contrasting it with that observed by Dr. Parsons in 1880, it is to be noted that the improvements effected by the Authority are neither numerous nor extensive.

The Highway Authorities have laid down during the last 10 years some 3 miles of 9″ and 12″ socketed pipes, for drainage of all the chief roadways not previously drained. Old brick-and-mortar culverts, about 2 feet in diameter, still, however, remain in use in Cradley proper (in the High Street, Butcher's Lane, and New Street). The socketed pipes are not cemented at the joints, and neither they nor the culverts have their inlets trapped. Road gullies are not provided with catchpits. For about a half of the dwellings, there are channels by which liquid refuse may find its way to these conduits, but most of the channels are circuitous,—mere tracks upon the surface, cut by the sewage in the loose soil, or bricked gutters many or most of them only dry-steyned; a few are covered, and these are commonly faulty as to the mode of their construction, trapping, and ventilation.

At one house, where typhoid fever occurred, there is a trapped indoor sink-inlet. A pipe-drain, consisting of socketed and cemented pieces, extends from this sink through adjoining premises to the old culvert in the High Street, and in its course through these premises, a trapped outdoor sink and the soil pipe of a water-closet discharge into it. There is no ventilation for any part of this drainage system. When the water-closet handle is raised, the indoor sink-trap is, it seems, sucked dry, and a "sickening" stench pervades the house. At another place the wash-water from the house passes by a gutter to the lower end of the garden, some 12 yards from the house, where it forms a swamp, and has to be removed by barrow. At another place an unventilated pipe-drain has been laid from the lower part of the wall (not from the floor) of a cellar to one of the old culverts.

Half or so of the house sewage, as well as filth from a few water-closets and slaughter-houses, passes into the highway drains, which ultimately discharge directly or indirectly into the river. These drains frequently become silted up in wet weather, owing, it is said, to the large amount of road detritus washed into them. This is formed in abundance from the slag of the iron-furnaces which is used as metal for the roads, and it is carried off into the drains, there being, as already said, no provision at the gully inlets for intercepting solid matters of this sort. Four of the main highway drains were blocked in this way quite recently, three of them at the time of my inspection. House-drains also are frequently blocked owing to a similar cause, and then, as in instances which came under my notice, a sewage swamp ensues and extends over several contiguous premises. It should be stated also that there is no public paving in the district; in the chief places there are kerbing and irregular channelling, but the footpaths are uneven, and, consisting, as they do, largely of ashes and slag, they add their quota to the sediment which tends to block the drains.

In cases in which liquid refuse from the house is not disposed of by way of the drains—and this holds of perhaps a half of the total—it is thrown on to the premises to soak, if it can, into the ground, or else to form swamps, as at Mill Street and Hightown. In many cases it passes into holes on the premises or into unventilated cesspools, which require no emptying, and from which it leaks away for years together, perhaps into cellars near at hand. From a particular group of houses it passes into a disused well; and in several cases it is disposed of in the midden.

Scavenging has, in obedience to an Order of the Local Government Board, dated January 25th, 1886, under section 42 of the Public Health Act, 1875, been carried out by the Authority under contract, the contract having been let for the current year at 65*l.* Last year it was let at 75*l.*, and in the previous year at 85*l.* The journal of the Inspector of Nuisances shows that 2,039 cartloads of refuse and excrement were removed from 1,292 premises in the year ending April 30th, 1887, and 1,834 loads from 1,533 premises in the year ending April 30th, 1889. Seeing then that the inhabited dwellings in 1881 numbered 988, it will be evident that scavenging of any one set of premises has not taken place on an average more frequently than once in six months. And as the premises are not taken in any regular order, not a few of them are overlooked from one year's end to the other.

The large deep open dilapidated middens remain as heretofore, though it is to be noted that 42 of them have been roofed over since the fever broke out. The walls of some of these middens have special openings for admission into them of liquid refuse from cottages and piggeries. In wet weather these filth-receptacles tend to overflow, and streams of liquid filth run over the premises, it may be beside the mouth of the well and towards the dwelling. Many middens adjoin, or stand immediately under the windows of, the dwelling or the forge-shop; one is beneath the living room of a cottage, being approached from a lower level; and others must needs be emptied through the cottage.

Instances of gross nuisance of similar sort are met with in all parts of the district. At the back of some houses in New Street there are several open and adjoining middens, which together occupy an area of about 4½ square yards; they practically form a single open cess-

pool. This filth-depository is not 8 yards from the houses, and only 3 yards above the well, towards which all soakage and overflow necessarily pass; and the water of the well, though used by the inmates of these houses, is "not fit for human being to drink, for it's full of insects, and smells when it's boiled." At Windmill a large part of the small outdoor premises of four cottages is occupied by open middens, piggeries, and swamps of liquid refuse from the cottages and piggeries; while two wells on the premises afford the sole supply of water to the cottagers. At another place a privy-vault over flows by a pipe into a small open wooden barrel, planted in the centre of a flower-bed, a few yards from the house; the pipe becomes frequently blocked; and the housewife then resorts to a broom-handle in order to force a passage down the pipe; in wet weather the barrel overflows and gives rise to much stench.

It should also be stated that piggeries, and large underground swill-cisterns (their contents often in a state of decomposition) are pretty numerous on house premises.

The water service of the South Staffordshire Waterworks Company, whose mains lie in most of the roadways, furnished supplies, at the time (1880) of the inspection by Dr. Parsons, to 195 dwellings; at the middle of last year to 443; and now, since the outbreak of fever, it furnishes supplies to 563, or rather more than half of the total number in the district. For the other dwellings water is got, as before, from a few wells sunk deeply in sandstone rock, or from a few springs in the fields, the water of which is taken either directly at the spring by dipping, or at a spout to which the water is conducted from the spring in ordinary field pipes. In some instances rain-water from the roof is the only supply. It should be stated that in Cradley proper 100 or more dwellings were supplied up to December of last year with water from the town well; but this well having been proved to be polluted was closed at that time, and tap water has since been largely substituted.

Mention may here be made of some of the local supplies. At Two Gates, where there are about 80 dwellings, 60 of them are supplied with water from some half dozen wells. Most of these have been found by the Medical Officer of Health to be polluted, and as matter of fact, the cottagers get their drinking water either from a particular private pump-well or from the "park spring." They are allowed access to the former only during wet seasons; at other times they must needs go to the spring, a distance, for some of them, of 600 yards there and back. The water of this spring collects to a depth of about half a foot in a small hollow on the slope of a grass field, and is fed from open fissures in the sandstone hill immediately above Again, water issuing from a spout in Spring Lane is resorted to by 12 to 40 cottagers, some of whom have to go half an hour's walk to get it; this spout is fed through ordinary field pipes laid superficially in a field now growing mangolds. A similar spout at Overend furnishes water for about 30 cottagers; it is fed from a spring in a field from which the water finds its way to the spout, first by an open ditch, and then through socketed pipes. At the time of inspection two or three loads of human excrement and manure lay over the course of the lower end of the socketed pipes. In the immediate vicinity of many of the wells there are open middens, piggeries, drains, sewage swamps, dumb wells, and the like.

Dwellings remain for the most part much as they were reported by Dr. Parsons, very dirty, badly ventilated, and quite commonly close and fusty. I am informed, indeed, that in the old dwellings no new window has been constructed, and no sealed window has been made to open

since his visit. Limewashing is a comparatively rare event; even many of the cottages that were invaded by fever, though still tenanted, remain as before, dirty and foul. It is true the inhabitants work in grimy atmospheres, that most of the outdoor premises are covered with coal-ash from the small forge-shops, and that much smoke is belched from the chimneys of this and the surrounding districts; but the dirtiness and offensiveness of the dwellings must in the main be attributed to want of ventilation, insufficiency of cleansing, and frequency of overcrowding.* It may be observed, also, that as the surface of much of the ground slopes sharply, many of the dwellings have been, so to speak, let into the hillside, and that they are unprovided with any special protection against the dampness, to which they are thus exposed.

Slaughter-houses and dairies are neither properly constructed nor properly managed. As regards the former, there are to be noted loosely bricked floorings, direct communication with the pound, faulty drainage, and other objectionable conditions. One of the dairies is in the undrained beer cellar of a public-house, the walls of which are covered with moist fungus, and the milk pails in this case are rinsed and left to dry in a small outhouse in which household washing is carried on.

Some of the schools are not well ventilated. Perhaps the worst off in this respect is one of the British schools, at which there is an average attendance of 100 to 120 infants, and the chief room of which is ventilated only by means of six windows, each of about $2\frac{1}{2}$ feet square, and none of them so situated in the walls as to secure proper ventilation for the upper half of the school room. In another of the British schools there is a pit in the floor of the chief room, in which the school sweepings are disposed of, and in which they are allowed to accumulate to an extent, as at the time of inspection, of a good-sized barrow load. At all the schools the old-fashioned middens remain in use, and scavenging of them is conducted only at intervals of about three months.

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Under the great variety of unwholesome conditions above enumerated, the persistence of filth disease is almost a matter of course, and its epidemicity is now and again to be looked for. On referring to Table A., which shows the yearly number of deaths registered in Cradley as due to enteric fever and certain other diseases, it will be seen that during the last $12\frac{1}{4}$ years, with a population in 1881 of 5,284, there have been as many as 46 deaths from this fever, distributed in the main in two smart outbreaks, one having occurred in 1877 and 1878, the other being that with which this Report specially deals. No doubt other deaths in the table are also to be regarded as due to enteric fever. Medical men practising in Cradley and the surrounding districts say that enteric fever is rarely absent from this area.

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* In a particular cottage four persons sleep on one bed in a room which has a cubic capacity of only 320 feet. There is no flue in this room, and there is but one window, which has an area of about $2\frac{1}{2}$ square feet, and this opens directly over an old-fashioned open midden.

App. A. No. 7.

On the Sanitary Condition of Cradley, and on Enteric Fever there; by Dr. Gresswell.

## Table A.

Showing the Numbers of Deaths registered Yearly in Cradley as due to Enteric Fever and certain other Diseases.

| Diseases. | 1877. | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. | 1889, up to April 7th. | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Enteric or typhoid fever - | 16 | 5 | 3 | 2 | 2 | 2 | — | 1 | — | — | — | 8 | 7 | 2 |
| "Fever" - - - | — | 1 | — | 1 | — | — | — | — | — | — | — | — | — | 3 |
| Enteritis - - - | — | 1 | — | 1 | — | — | — | — | — | — | — | — | — | 6 |
| Gastric catarrh - - - | — | — | — | — | — | — | — | 1 | 1 | — | — | 1 | — | 7 |
| Cerebritis - - - | — | 2 | — | — | — | — | — | — | 1 | 1 | 1 | 1 | — | 7 |
| Meningitis - - - | 1 | — | — | — | 1 | 1 | — | 1 | 1 | 1 | 1 | — | — | 1 |
| Tubercular meningitis - | — | 1 | — | 1 | 1 | 1 | — | 2 | — | — | 1 | — | — | 1 |
| Cerebro-spinal meningitis - | — | — | — | — | — | 1 | — | — | — | — | — | — | — | 46 |
| Acute peritonitis - - | — | — | — | — | — | — | — | — | — | — | — | 1 | — | 30 |
| Tabes mesenterica - - | — | 3 | — | — | — | — | — | 1 | 2 | 2 | 2 | — | — | 10 |
| Diarrhœa - - - | — | 1 | 1 | 2 | 2 | 3 | 1 | 3 | 2 | 5 | 2 | 8 | — | 2 |

It will also be observed that the numbers of yearly deaths from infantile diarrhœa in Cradley (all but two of the deaths from diarrhœa recorded in the table have occurred at ages under five years) have been on some occasions excessive.

In Lye and Wollescote parishes, with a total population in 1881 of 9,382, adjoining Cradley, and like it forming parts of the Rural Sanitary District of Stourbridge, the following with other deaths were registered for the period from the beginning of 1879 to the end of 1888, viz., 67 from typhoid or enteric fever, 16 from febricula, 1 from continued fever, 2 from typhoid pneumonia, 1 from acute gastritis, 6 from enteritis, with or without peritonitis, 1 from typhlitis, 9 from meningitis (simple or tubercular), 1 from meningo-encephalitis, 7 from cerebro-spinal meningitis or cerebro-spinal fever, 4 from cerebritis, 4 from tubercular peritonitis, 6 from acute peritonitis, 2 from infantile remittent fever, 1 from vermicular fever, 1 from dysentery, and 81 from diarrhœa.

At Pensnett, Bromley, Brockmoor, and Wordsley, also in the Rural Sanitary District of Stourbridge, there were 16 deaths from enteric fever in the year 1888, a matter which formed the subject of some notes to the Board by Dr. Parsons in November of that year.

It may be remarked also that in five parishes near to Cradley, viz., Hill, Halesowen, Lapal, Hasbury, and Hawn, with a total population in 1881 of 8,630, there were among persons under 5 years of age 25 deaths attributed to diarrhœa, gastric, gastro-enteric, and enteric catarrh in the period from May 27, 1888, to May 9, 1889.

Quite possibly the circumstance that the children of Cradley and of the surrounding districts are so commonly infested with "round worms"—the fact as to which is attested by each of the medical practitioners with whom I was brought into communication—is, in a measure, the result of the foul condition of outdoor premises. The filth heaps and the sewage swamps, on and about which the children spend much of their playtime, must contain exceptional numbers of the ova of this parasite, which in dry weather could be carried by almost every gust of wind into the dwellings, and so get abundant opportunity of lodgment in food.

*The Enteric Fever Outbreak.*

Special attention has now to be given to the recent outbreak of enteric fever in Cradley. For a knowledge of the cases I am indebted to the medical men of the district, who were good enough to give me full information concerning the persons whom they had attended. It is perhaps needless to say that there must have been persons in many households, who, though in all probability suffering from enteric fever, received no medical advice. Taking cognizance of all cases that came to my knowledge as having occurred between the date of inspection (June 10th, 1889), to as far back as December 11th, 1887, prior to which for three years there had been no *death* from this disease in Cradley itself, it appears that 52 dwellings were invaded; out of the 316 inmates of these dwellings, 113, or 35·7 per cent., manifested symptoms of the disease, and 16 of the latter, or 14·1 per cent., died.

The incidence of the disease on several age-groups is shown thus:—

Of the inmates of the 52 invaded dwellings—38 were under 5 years of age; of these 4 were affected, *i.e.*, 10·5%, and none died, *i.e.*, 0·0%; 46 were 5 to 10 years of age; of these 22 were affected, *i.e.*, 47·8%, and 2 died, *i.e.*, 9·0%; 47 were 10 to 15 years of age; of these 27 were affected, *i.e.*, 57·4%, and 4 died, *i.e.*, 14·8% ; 38 were 15 to 20 years of age; of these 18 were affected, *i.e.*, 47·3%, and 1 died, *i.e.*, 5·5%; 147 were over 20 years of age; of these 42 were affected, *i.e.*, 28·5%, and 9 died, *i.e.*, 21·4%.

The gravity of the disease in relation to age of the patient was that usually observed in epidemics of enteric fever. And similarly, the customary prevalence of the disease in relation to season was duly observed, the number of households invaded in different months having been as follows:—

1887.—December, one.

1888.—February, one; March, one; May, one; July, one; August, two; September, three; October, three; November, sixteen; December, eight.

1889.—January, nine; February, three; April, three; May, none.

As regards localization of the disease, the following facts are worthy of notice. In Cradley proper 47 dwellings were invaded; 104 of their 283 inmates were affected, and 12 died. In the rest of the district 5 dwellings were invaded; 9 of their 33 inmates were affected, and 3 died. Again, in the outbreak in 1877 and 1878 the deaths in Cradley proper numbered 14; and those in the rest of the district 7. Hence in the recent outbreak the proportion of deaths in Cradley proper to the total of enteric fever deaths in the parish was 80·0%; and in the earlier outbreak it was 66·6%, proportions which fairly coincide with those in which the population is distributed in these respective areas.

The question now arises as to the cause of the exceptional prevalence and fatality from enteric fever last year. The fact that the distribution of the deaths in this epidemic, like that in the epidemic of 1877 and 1878, so nearly coincided with the distribution of the population, would suggest similarity of the conditions under which the disease was fostered on the two occasions. Also the facts are consistent with presence of a well-nigh ubiquitous fever-virus, which was but awaiting the necessary conditions, seasonal and other, for manifesting itself by epidemic spread of disease. And in this connexion it deserves notice that in both epidemics at Cradley enteric fever exhibited its commonplace seasonal behaviour. But season, though operating in its own way (at one time inhibiting, at another fostering potency of the virus) must be regarded as powerless to bring about an epidemic without assistance from other

conditions favouring multiplication of the virus, and securing wholesale dissemination of the multiplied material among persons susceptible to the particular disease.

As matter of fact, of the various conditions requisite for enteric fever prevalence the chief of them were operative at Cradley, viz., fever-virus aforetime distributed about the district, and as well peculiar facilities for multiplication and dissemination of such virus when the time for its seasonal activity had arrived. Among many means in Cradley for dissemination of virus of the above sort a particular local water supply deserves especial notice.

It appears that on December 6th, 1888, the Medical Officer of Health finding that there had been a remarkable incidence of the disease upon persons using the water of the town well, sent a sample of this water for analysis to Dr. Swete, the county analyst. Dr. Swete reported the sample to be "largely polluted with organic matter"; and the well was accordingly closed on December 10th. By this time 33 households had been invaded. Of these, 22 had been using this well water daily; five others had become invaded through school children, who it is said in all probability drank of the same water while on their way to or from school; while two other primary cases were referable to secondary infection; so that invasion in 29 cases out of the 33 may be regarded as having been due possibly to this water.

Further, if an incubative period of two or more weeks be allowed, cognizance must be taken also of four other households invaded within such period after the closing of the well. For one of these the water had been always taken from the well; two others were invaded in the persons of school children, who are said to have drunk water from the well; and one was clearly a secondary case.

Hence of the 37 households invaded by the end of the year, 33 may be regarded as having possibly got their infection through this particular water.

Of households later invaded there were 15. Four of these may easily have derived their infection from prior cases, with which they had been in relation; leaving 11 primary attacks to be otherwise accounted for. In this connexion it is of importance that only one of the 11 occurred in a locality which had not been affected with fever in recent months, and that in this case the person who introduced fever into his family was employed in an adjoining district, where also the fever was prevailing at the time. In the second place it is of importance to bear in mind the circumstances obtaining in the district by the time the well was closed.

Specific stools had now been deposited in almost all parts of the fever-district in middens, most of which were used by more than one family, and in particular instances, by as many as half-a-dozen or more. Liquid refuse from invaded cottages was now flowing above the surface in a variety of places, even by the very doorways of the cottages. Ill-constructed drains, public and private, having received specific typhoid matters, were giving egress to their emanations at many an inlet. Water supplies, almost of necessity specifically polluted were in common use. Children (through whom 8 of the 11 households were invaded) were at play in the sewage gutters and about the filth heaps on the premises. Poultry, at one moment investigating the filth out of doors, were at another mingling with the family in the cottage. School children (through whom 7 of the 11 households were invaded) had to pass daily on their way to school along a very narrow lane (Banklays) bordered on one side by a row of five dwellings (mere hovels) each of which, save perhaps one, had already contained one or more typhoid

patients, and which were (and indeed remain now) unprovided with proper drains or with proper filth receptacles; and school children had to make use of the filthy old-fashioned middens provided by the school authorities, and into which typhoid stools had certainly been passed. Persons from invaded households were now distributed day by day in various parts of the district, at school, in the mines, and in the forge shops. Moreover, dairies, cowsheds, and slaughter-houses remained altogether unregulated, and it is known that in one case a member of an infected family for some two weeks or so spent the night at her home and the day among the milk pails at a dairy. And not least, there is the fact that the measures adopted by the Authority in dealing with the fever-prevalence did not include any definite attempt at isolation of the sufferers, or any real improvement in the filth receptacles or of the drainage, not even compulsory cleansing of dwellings, wherein whole families had suffered from the disease.

If regard be had to these various circumstances, it will be evident that facilities for acquiring infection after the well was closed were as abundant as they were diverse; and that therefore the precise influence, in spreading the fever, of one or another of them can be but matter for surmise.

Attention has now to be given to the construction of the particular well, and to the likelihood of its having received typhoid matters.

The well is an old heading, 16 feet long, 12 feet deep, and 9 feet broad, driven horizontally into the solid sandstone almost completely across and beneath the High Street, the internal surface of the crown of the heading being about $3\frac{1}{2}$ feet from the surface of the street. The mouth of the heading is bricked up, and the water flows into, and accumulates in, the reservoir, or well thus formed, from fissures in the wall at the further end. An old brick-and-mortar culvert in the street, laid at a depth of about 18 inches from the surface, commences only a little higher up the street, 4 yards above the well, passes by the further end of the well at a distance of 2 feet from it, and thence down the street to discharge into the river. Twenty yards or so from the further end of the heading, and on ground which rises therefrom somewhat steeply, there are the churchyard with the church in its centre, and the row of dwellings called Banklays, drainage from the latter passing into the upper end of the culvert in question. The water of the well is derived from the sandstone of this hill, in the superficial layers of which are the graves of the cemetery, uncovered middens, slopholes, and leaking drains. And the tracks, by which water passes to the well, may have been considerably disturbed last year; for the church and other buildings on the hill were at that time damaged by subsidences resulting from mining operations.

It is supposed that pollution of the water of the town well may thus have been brought about. But it should also be stated that certain alterations in the physical circumstances of the well, purposely undertaken last autumn, may also have had concern in it. Water used to be drawn from the well by pumps at the outer end of the heading, but in September 1888 the pumps were placed at the other end, holes being driven with pickaxe and chisel through the roof of that end of the well for the passage of the pump pipes, and it has been thought that the 2 feet of rock separating the culvert from the well may then have been cracked so as to allow leakage from the former into the latter.

And it is quite possible that the water may have received *specific* pollution from the culvert. In February 1887, the occupants of one of

the five dwellings in Banklays, liquid refuse from which would pass down the Banklays drain, and so into the culvert, suffered from typhoid fever, contracted, I am told, whilst nursing some relatives ill of that disease in an adjoining district. And it further appears that this family continued to suffer on and from enteric fever for many months; and that, so recently as November of last year, two members of this household were attacked by unquestionable enteric fever.

It especially deserves notice that this very water supply was emphatically pointed out to the Authority by Dr. Ballard in 1873 as a source of grave danger; that the epidemic of enteric fever in 1877 and 1878 was ascribed by Dr. Thompson, then Medical Officer of Health, and by several other practitioners to pollution of this same water; that Dr. Parsons spoke in no hesitating terms of the danger to which Dr. Ballard had previously called the attention of the Authority; and that the vicar in the pulpit and elsewhere stated that the persons who drank of this water "were drinking deadmen's bones." Nevertheless the water continued in use.

## No. 8.

### Report on an Epidemic of Enteric Fever in the Northern Division of the Houghton-le-Spring Rural Sanitary District, County of Durham; by Dr. David Page.

On the 24th of April 1889 the Board received a communication from Dr. Park, Medical Officer of Health of the Northern Division of Houghton-le-Spring Rural Sanitary District, to the effect that an epidemic of enteric fever, associated with a certain amount of what he described as a low form of pleuro-pneumonia, had broken out at New Herrington and other villages of that district. As the result of his inquiries, Dr. Park had found that while some of the cases presented symptoms of pleuro-pneumonia only, others were genuine cases of enteric fever ushered in by pneumonic symptoms. These observations, in which other medical practitioners of the district concurred, had been confirmed, Dr. Park stated, by Dr. Phillipson, of Newcastle-on-Tyne, Professor of Medicine in the University of Durham, who had been called in consultation. So sudden had been the outbreak that between the 16th April, when Dr. Park's attention was for the first time called to it, and April 24th upwards of 100 cases had come to his knowledge. Dr. Park also reported that he was able to exclude the milk supply, derived as it was from various and independent sources, from implication in the outbreak, and that one or two cases only were found associated with local defects of drainage or the like. As regards purity or otherwise of the water supply in common use in the affected localities, Dr. Park was at the date of his communication to the Board unable to make any statement, as he had not then received the report of the analyst, to whom a sample of the water had been submitted. Two days latter he transmitted to the Board a copy of the results of analysis of the sample in question. It had been taken from a tap in George Street supplied from the water reservoir at Herrington. (*See* Addendum No. I., sample (*a*.).)

Of the particular sample, the analyst reported:—"Microscopical "examination satisfactory. This water is very free from indications of "organic impurity. I am of opinion that it is a good water for drinking. The amount of total solid matter in solution is somewhat large, "and it will therefore be somewhat hard."

On May 2nd I received the Board's instructions to make inquiry into the outbreak, and on the following day, accompanied by my colleague Dr. Ballard, I visited the district. I owed the advantage of Dr. Ballard's co-operation in the early stages of the inquiry to the circumstance that it was desired to learn whether there were any points of similarity between cases of pneumonia in this outbreak and the cases

of "pneumonic fever" in the epidemic investigated by Dr. Ballard at Middlesbrough-on-Tees in the spring of 1888.

As respects this question, the late period of the epidemic at which the inquiry was commenced, and the absence of all opportunity for post-mortem examination, prevented definite result being arrived at. There appear, however, to have occurred, in and about Herrington, three classes of illness in which pneumonia was a prominent symptom:—1. There were cases in which the illness began and ended as pneumonia, no illness of the nature of enteric fever succeeding it. Such cases were observed outside the area invaded by the enteric fever as well as within that area, and were not much more abundant than has been customary in the district at the same period of the year. Two instances, within the fever-infected area, were brought to our notice, in which two persons in a house were attacked by pneumonia. In one, two sisters, aged respectively 11 and 13 years, were attacked with pneumonia, the first on April 3, the other on April 15, and both recovered without giving any evidence of enteric fever. In the other instance, a boy aged 16 was attacked with pneumonia on April 13, and on April 20 a man aged 64 residing in the same house was similarly attacked: in neither of these cases was there any evidence of enteric fever, and both of them made good recoveries. These might or might not have been instances in which the pneumonia was communicated from the sick to the healthy; we heard of no other instances in which the quality of communicability could be suggested. 2. There were cases in which the illness decidedly commenced as pneumonia and went on apparently uncomplicated to the period of crisis or until the pneumonia began to subside without crisis. But the patient instead of thenceforward steadily improving began to exhibit the distinctive evidences of enteric fever; diarrhœa and rose spots made their appearance, and the case proceeded as one of enteric fever to recovery or death. This class of case of illness was only observed, or most prominently observed, during the first fortnight or so of the epidemic outbreak about a third of the enteric fever cases at that time having commenced in that way. To Dr. Park belongs the merit of having noted the peculiarity of the epidemic.* 3. Lastly, there were cases in which obvious pneumonia did not occur until the enteric fever had made more or less considerable progress, or towards the later stage of the malady. Dr. Park regarded these cases as congestive,—as the sort of pneumonic complication which he, with other observers, had been previously more in the habit of meeting with in enteric fever. As the epidemic drew to a close even these cases were rare.

The locality affected by the outbreak under consideration comprises a series of villages connected with collieries belonging to the Earl of Durham, and extending from New Herrington four or five miles in a

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* The following is Dr. Park's clinical description of this precursory pneumonia:—"The cases started suddenly, usually with rigor, but in some with vomiting and purging. The maximum temperature, 102–104°, was reached almost at once. There was great prostration. The pulse was small and receded quickly from the finger, and ranged from 100 to 120 a minute. The respiration was quickened, and there was dulness at the base of one or both lungs. The tongue was generally flabby, moist and clean, or only slightly covered with a thin white coat. The flushing of the face was also a common feature, and drawing the nail across any part of the body produced a deep red mark in almost all the cases, lasting for several minutes. The cough was usually insignificant but frequent, and the expectoration occasionally rusty, but more often white and very tenacious. In about six of the cases epistaxis has been present."

south-westerly direction. Intercommunication between these villages on the one hand, and the neighbouring town and Urban Sanitary District of Houghton-le-Spring on the other, is very close. But in regard to their circumstances of sewerage and water supply there are important differences. As to sewerage, they possess nothing in common, each village, and in very many instances each separate row of houses, having its separate sewers and sewage outfall. As regards water service, however, they have more in common. There are two different supplies within this area, namely, the Houghton supply and the Herrington supply. It is in the villages dependent upon the latter service that the epidemic has almost exclusively prevailed. During the time covered by the epidemic 17 cases only of enteric fever are known to have occurred within the area of the Houghton supply in a population of some 12,000, while in the area of the Herrington supply, which comprises a population of some 4,400, not less than 258 cases of enteric fever came under notice. These figures do not include cases which occurred at the same time in villages of the neighbouring Chester-le-Street Rural Sanitary District into which the Herrington water supply extends. (*See* page 64.)

This localisation of the fever in villages situated along a particular line of water supply, together with the immunity of neighbouring villages which differed from them only in the matter of water service, led early to a suspicion that drinking water was concerned in the outbreak.

At the outset of my inquiry, in conference with Mr. Morton, agent to the Earl of Durham, Mr. Lishman, manager of his Lordship's collieries, and Dr. Park, it was decided, in view of the *primâ facie* evidence against the water supply from the Herrington service—which, indeed, now received support from the results of further chemical analysis (*see* Addendum No. I. (*b*)), report on which came to hand May 3rd—to warn consumers of the advisability of boiling the water before drinking it. For the rest I found that Dr. Park and the Sanitary Inspector, Mr. Osselton, had already adopted a number of necessary preventive measures, while the personal wants of the sufferers were being well attended to by trained nurses, and by a band of ladies organised for the purpose of attendance on the sick poor by the Rev. Canon Body of Durham.

From the first appearance of symptoms in the earliest cases which came under notice, the epidemic may be said to have begun in the first week of April, to have continued unabated throughout that month, into the first week of May, and thenceforward to have declined. By June 7th the epidemic was virtually at an end. Between April 1st and June 7th 275 cases are known to have occurred in the district.

The following is a weekly list of these cases :—

| Newly occurring in the Week ending | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| April | | | | May | | | | June |
| 7th. | 14th. | 21st. | 28th. | 5th. | 12th. | 19th. | 26th. | 2nd. |
| 33 | 66 | 68 | 45 | 29 | 11 | 16 | 6 | 1 |

In the majority of the cases enteric symptoms were well marked. The deaths were 26 in number = 9·5 per cent. of the attacks.

The following table shows the distribution according to sex and age :—

| Sex. | At all Ages. | Under 5. | 5-10. | 10-15. | 15-25. | 25-45. | 45+ |
|---|---|---|---|---|---|---|---|
| Males - - - | 132 | 8 | 29 | 27 | 50 | 12 | 6 |
| Females - - - | 143 | 10 | 28 | 40 | 35 | 25 | 5 |
| Total - - - | 275 | 18 | 57 | 67 | 85 | 37 | 11 |

In a total number of 190 households invaded, multiple attacks occurred in 45, or nearly one fourth.

From the painstaking and complete character of Dr. Park's inquiry, very little investigation served to confirm the conclusion that this outbreak had nothing to do with milk supply, and that commonplace local sanitary defects, which could at most account for two or three cases, must be altogether set aside. The house accommodation of the affected villages is of a distinctly superior kind to that met with in many colliery districts. There are no drain-connexions inside the dwellings. The removal of house refuse is undertaken by the colliery authorities, and, for the rest, the sanitary circumstances of the district are carefully supervised by the officers of the Sanitary Authority.

It has already been stated that, with few exceptions, the epidemic was confined to the area of the Herrington water-supply; 258 cases out of the total 275 having occurred within this portion of the Houghton Rural Sanitary District. Of these 258, 163 occurred in the rows and groups of houses known as New Herrington, and 95 in those forming the villages of Junction Row, Success, and Philadelphia. The incidence of attack in point of time would appear to have been somewhat later as the distance from the Herrington reservoir increased. Thus the localities named were attacked during the first week of April, whereas cases occurring on the confines of the district at places where the pipes extended into the Chester-le-Street Rural Sanitary District, were apparently not attacked before the 12th of April.

In reference to the latter district, I may here note that the majority of the Chester-le-Street cases occurred at New Lambton, a colliery village immediately adjoining Houghton-le-Spring Rural Sanitary District, and some three miles west of Herrington. Here, and at the neighbouring village of Burnmoor, some 26 cases are known to have occurred, three ending fatally during April and May. Beyond these villages a few scattered cases at the same time occurred at houses and groups of dwellings getting water from the terminal mains of the Herrington service. I visited these localities, accompanied by the Chairman and the Medical Officer of Health of the Chester-le-Street Rural Sanitary Authority, and learned that enteric fever was entirely confined to those portions of that district.

Throughout the whole epidemic, the Urban Sanitary District of Houghton-le-Spring, with a population of 6,640, and the villages of Newbottle and Sunniside, which together have a population of 2,260, remained free from fever; while in Dubmire, with a population of 1,300,

two cases only, and in the villages of Shiney Row, Whitefield Pit, and Painshaw (with an aggregate population of 2,100), 15 cases only came under notice. The town and the other places named derive their water-supply from the Houghton service. The villages of Sedgeletch, West, East, and Middle Herrington, situated in the epidemic area, but getting their supply from local wells and springs, also remained quite free from fever.

As regards the 17 cases mentioned as occurring in Houghton-le-Spring Rural District within the area of the Houghton water-supply, Dr. Park had ascertained that in all, save two instances, there was a distinct history of exposure to the influences existing within the affected area, and on further inquiry by myself this was confirmed.

I have now to describe in detail the water-service of the affected area. The Herrington supply is pumped from a well or "staple" sunk to a depth of 330 feet into sandstone strata of the Coal Measures, into a service-reservoir holding 30,000 gallons, from which it is distributed by gravitation. This well, which was sunk some 15 years ago for the special purpose of the water-supply of this district, is above the level of the colliery workings, and has no communication with them. For the first 72 feet it passes through clay with sand partings or seams; for the next 15 feet through limestone marl; and for the remaining distance through beds of sandstone and shale. The sides of the well are lined with bricks set in mortar, and up to the period of my inquiry were believed to be impervious, the water being described as entering the well at the bottom. The reservoir into which the water is pumped is placed some 60 feet above the ground, on the top of the engine-house. It is uncovered, and the overflow or waste-pipe discharges in the open air into the adjoining colliery pond. The outlet or descending main, seven inches in diameter, is carried along the colliery railway for a distance of 570 yards to a point where the line is crossed by a highway bridge. From this point it continues for 150 yards, side by side with, and at a slightly lower level, than a 6-inch drain coming from "Herrington Inn." At a distance of 1,450 yards from this point the water-main effects a junction with the Houghton service. The object of this communication with the Houghton mains is to enable the Houghton water to be turned into the Herrington district, during periods of intermission of the Herrington service for purposes of cleansing and repair at the reservoir and pumping-station. The distribution of water over the district is effected by service mains of four and of three inches in diameter. For some weeks prior to the outbreak the sole intermission of this kind had occurred on one date only, namely, March 6th, when the Houghton water was turned on from 7 a.m. until 4 p.m., an interval of nine hours. With this exception the Herrington service district had been continuously supplied from its own proper reservoir. The water of the Herrington well had not been used to supply the Houghton water district.

Situated on the further side of the pumping station is a row of houses, New Pit Row, which receive a separate supply directly from the reservoir, delivered in a direction opposite that taken by the 7-inch descending main. This row has also a separate sewer, with outfall into a neighbouring stream. In this New Pit Row three families were attacked with enteric fevor between April 1st and April 11th, there being altogether five cases.*

* It deserves to be noted that, when the Houghton supply is turned on it cannot reach New Pit Row, and the people there are compelled to draw water the night before from the reservoir.

The first service-pipe given off from the 7-inch main is a 2-inch pipe for the supply of the next and lower row of houses, Railway Terrace, and this ends at a stand-pipe there. Railway Terrace comprises 53 households, of which 12 have been attacked with fever, there being altogether 22 cases, of which the earliest occurred on the 1st of April. The next service-pipe is given off shortly below the bridge mentioned above as crossing the railway and supplies the rest of the village of New Herrington. Of the several rows and terraces of houses in this part of the village, Travers Street, containing 26 houses, was also early attacked, 13 cases occurring in 10 families, the earliest on the 5th of April. This row has an independent sewer and outfall. Single Row, in the same village and containing 40 houses, also having a separate sewer and outfall from the rest of the village, was attacked about the same time; the earliest house was invaded on the 4th of April; 14 cases occurring here in 11 families.

From the distribution of the fever over the whole line of the particular water-service, including, as now shown, its highest as well as its lowest points, it became evident that contamination of this service near its source would alone explain the circumstances of the outbreak.

Although the early occurrence of cases in New Pit Row, as well as in Railway Terrace, was inconsistent with the view that pollution of the water had taken place in its passage through the service pipes and thus brought about a general specific contamination of the supply, I thought it desirable to examine the relations of the main and the sewer where these were contiguous by the side of the railway. This was accordingly done, and both were thoroughly exposed in their entire length. As a result the sewer was found to be leaking at several points, but the water main was quite intact, the joints of the latter, although carefully cleansed all round and tested for some time under full pressure, showing not the slightest sign of wetness. This main, I was told, had been renewed some six years ago, and the joints were then made tight by means of india-rubber rings. Although lying within a yard of the railway metals, and exposed, therefore, to more or less vibration, the integrity of the joints had apparently suffered in no way. Examination of the service-pipe to Railway Terrace was also made, but it was found to have no dangerous relation to sewers.

Examination of the immediate surroundings of the reservoir and the well was next made. In this neighbourhood a deposit of privy and ash-pit refuse from houses in Railway Terrace lay at a distance of 150 yards on one side of the well, while on the other side of it, in a grass field and at about the same distance, lay the remains of a deposit of night-soil brought thither by rail for agricultural purposes from South Shields and Sunderland. Both localities had been used for the purpose of such deposits during the last 15 years. It was seen to be possible that one or other of the deposits in question had had somehow or other to do with infection of the water service. It was suggested, for instance, in explanation of the outbreak that infective dust carried by the wind from one or other of these deposits might have gained access to the open tank. As matter of fact, on May 4th, when the tank was emptied and cleansed, a black deposit of about an inch in thickness was removed therefrom. This deposit presented to the eye the ordinary appearances of coal dust, but had a smell suggestive of decaying vegetable matter. The deposit had accumulated since the previous emptying and cleasing of the tank on April 5th. Giving all possible weight to this suggestion, it fails satisfactorily to explain the suddenness of the outbreak and continued infection of the water, especially in view of the cleansing of the tank once a month and the absence of opportunity for

stagnation of the water, which from the small size of the reservoir was continually flowing in and out. Moreover, to fit all the facts of the outbreak, such a theory would require nothing short of the continued daily access to the tank of infective material in the shape of air-borne dust for a limited period coincident with the incubation of the early cases and as sharply defined in its limits as the outbreak itself. Another and more likely method of infection of this water service appeared to exist in the possible percolation from one or other of those heaps of excremental matter into the well, and excavations were accordingly made with a view of testing this point. Trenches were dug to the depth of several feet into the soil about them, and they were found to rest on a compact and impervious clay, and in neither case was any trace of wetness showing percolation met with in the trenches. But it has also been stated that the field in which the deposit of night-soil lay, which was some 30 acres in extent, had been manured in October 1888 (as in the autumn of previous years) over about a third of its area with some 60 or 70 tons of these matters; percolation from such a surface would doubtless be considerable, and might, under conceivable circumstances, reach the well. I may note that the rainfall, January to March 1889, was 4·8 inches as against 7·32 inches in the corresponding period of 1888.

At this stage of the inquiry Mr. Lishman was good enough to have the "staple" or well carefully examined, and on May 23rd he informed me that as a result, and contrary to previous belief that the walls were impervious, a small "feeder" of water was found to enter the "staple" on the south, at a distance of 45 feet from the surface, issuing from the brickwork at the rate of 22 gallons per minute. A sample of this water had been sent for analysis and the following report received.—

| | |
|---|---|
| "Colour and appearance in 2-foot tube | Very turbid. |
| "Smell at 100° F. | None. |
| "Chlorine in chlorides | 3·459 per gal. |
| "Nitrogen in nitrates | Nil. |
| "Phosphoric acid in phosphates | Nil. |
| "Ammonia | 0·002 per gal. |
| "Albuminoid ammonia | 0·006 ,, |
| "Oxygen absorbed at 80° F. in 15 minutes | 0·05 ,, |
| " ,, ,, ,, 4 hours | 0·087 ,, |
| "Total solid matter dried at 220° F. | 52·1 ,, |
| "Solid matter in suspension, chiefly mineral | 10·44 ,, |
| "Lead and other poisonous metals | Nil. |

"Microscopical examination, chiefly mineral matter. This water contains indications of organic impurity, which make it of somewhat doubtful fitness for drinking. In the condition as received it contained so much matter in suspension as to be unfit for use without previous filtration."

The extra amount of chlorine in this sample, 3·4 grains per gallon, as compared with 2·2 grains per gallon shown in previous analyses of the well water, is an interesting point in connexion with experiments which will be described later, and which were undertaken with a view of discovering the source of this polluted and hitherto unsuspected supplemental supply. With reference to prior analysis of the Herrington water supply I have already stated that the water (Addendum No. I., sample (*a*)) was reported upon April 24th as satisfactory for drinking purposes. A similar report, the result of a later analysis, was received on May 3rd (*see* Addendum No. I., sample (*b*)).

App. A. No. 8.

On Enteric Fever in Houghton-le-Spring R.S.D.; by Dr. Page.

On May 1st, however, another sample (*d*) taken from the same tap as samples (*a*) and (*b*) had been reported upon by another analyst as follows:—

"The analysis is fairly satisfactory from a chemical point of view, with the exception of the ammonia, which in my opinion is evidence of sewage pollution of recent date. The microscopical examination, which has been made with scrupulous care, shows that the water possesses highly objectionable features. The presence, for instance, of dyed cloth fibres and starch granules, which proved to be granules of arrowroot starch, is exceedingly suggestive of contamination with household refuse. I have no hesitation in saying that such water as this is unfit for public consumption and is a source of danger to the public health." (Addendum No. I. (*d*).)

Samples taken on May 7th directly out of the reservoir had been submitted to the same chemists. One report, on sample (*c*), stated:—

"Microscopical examination, satisfactory. This water is very free from organic contamination and quite suitable for drinking purposes."

The other report (sample (*e*)) was as follows:—

"Microscopic examination. Starch granules (bean, oat, and barley or wheat), fungoid growths, moving organisms (various), vegetable *débris*, broken hairs, paper, and other domestic fibres. The water is not satisfactory as a drinking water. I consider the ammonia to be evidence of recent sewage pollution. I take this item in connexion with the microscopical examination, which is of sufficiently suggestive character. I am distinctly of opinion that unless a very satisfactory explanation of the presence of the ammonia to which I allude is forthcoming the water cannot be considered safe for domestic supply." (Addendum No. I., samples (*c*) and (*e*).)

A third sample taken from the reservoir at the same time had been sent to Dr. Dupré, from whom the following report was received on May 17th:—

"The water is slightly turbid, and on standing yields a trace of deposit consisting chiefly of mineral matters but containing various fungoid growths and a few animalculæ. It is hard, but becomes moderately soft on boiling. The presence of ammonia and the somewhat high proportion of albuminoid ammonia yielded indicate some pollution, which, however, appears to be mainly at least of a vegetable character. The water is decidedly less pure than the sample of water examined for the Houghton-le-Spring Union Sanitary Authority in 1885 and reported upon on September 22nd, 1885. It would therefore be advisable to examine the reservoir as well as the source of the supply, with a view to discovering and, if necessary, removing any source of pollution." (*See* Addendum No. II.)

In looking around beyond the immediate vicinity of the well for possible opportunities of contamination, I had visited early in my inquiry the farmhouse of Herrington Hill. This is situated about three-quarters of a mile to the south of Herrington Colliery on rising ground and about 150 feet above the level of the surface at the well. The farmhouse and buildings are upon the magnesian limestone, the beds of which dip towards the north. Owing to subsidences caused by the colliery workings below, fissures extending to the surface exist in this locality. The drainage of the farm buildings, of a cottage, and of the farm-house itself (in which latter there is a watercloset) is conveyed to a tank. The over-flow from this tank escapes and disappears down an adjoining fissure in the ground. To determine whether a connexion existed

between this fissure (three-quarters of a mile from the well) at Herrington Hill farm and the water-bearing strata supplying the "staple," I suggested that common salt should be dissolved and thrown down the fissure. Instructions were given to this effect and two tons of salt were accordingly thrown down on May 11th. At this date the discovery of the "feeder" in the "staple" had not been made, and testing of the water as pumped from the well did not give any conclusive indication of increase of chlorides. On the discovery of the "feeder" a week later, a clue to the excess of chlorides shown by it (as compared with the body of water in the well) was apparently furnished, and, as will presently appear, the source of the chlorides was in the end conclusively demonstrated. From May 24th a series of daily testings of the relative amounts of chlorine in the water of the reservoir and of the "feeder" was made. The chlorine in the water of the reservoir varied from 2·3 to 2·8 grains per gallon; that in the "feeder" from 4 to 6 grains per gallon. On May 29th with a view of placing beyond doubt whether the increase of chlorine thus shown was due to the salt thrown down the crevice at Herrington Hill, 5 tons of salt were washed down the crevice with a hose-pipe running for 12 hours, during which time it was estimated that some 100 tons of water were discharged. On the following day the chlorine present in the water of the "feeder" rose to 15 grains per gallon. The testing was continued for a few days longer, and on June 5th the chlorine reached the maximum amount of 24 grains per gallon. During the next few days it fell again to the former amount. The connexion between the two localities, the farm-tank and the "staple," was thus conclusively established and the source of excremental contamination of the water supply demonstrated. Specific contamination of the sewage from the farm-house could not, however, be made out, no illness of a character resembling enteric fever having been known to occur at the farm during recent years.

It remains to add that since the discovery of the "feeder," arrangements had been made by Mr. Lishman for the supply to the affected district of water for drinking purposes from wholesome sources. Warnings had been issued to the people against resorting to the tap-water for drinking purposes, and it was further decided to abandon the Herrington water as a source for domestic supply. To meet the immediate exigencies of the case, and to guard against danger from a continued distribution of this water, the Houghton service was turned on and distributed through the Herrington mains for two hours night and morning. But as this supply was insufficient to meet the requirements of the whole of the district, arrangements were made and actually carried out for boiling the supply pumped from the Herrington well before it entered the reservoir. Engine boilers, which were fortunately at hand, were erected and adapted to this purpose, and on June 2nd these arrangements were completed and in operation. On the occasion of my final visit to the district on June 7th, I witnessed the remarkable and unique instance of the delivery to the mains of a water supply which had been actually submitted to a boiling temperature.

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On Enteric Fever in Houghton-le-Spring R.S.D.; by Dr. Page.

# ADDENDUM No. I.

## Summary by Dr. Page of the Analyses of Herrington Water, with Extracts from the Notes by the respective Analysts.

| Analyst. | Pattinson. | | | Stock. | |
|---|---|---|---|---|---|
| Date of Report. | Sample (*a*) [April 24th]. | Sample (*b*) [May 3rd]. | Sample (*c*) [May 11th]. | Sample (*d.*) [May 1st]. | Sample (*e*) [May 10th]. |
| Colour and appearance in 2-foot tube. | Colourless and nearly clear. | Colourless and nearly clear. | Colourless and nearly clear. | Slightly green, almost clear. | Faint green, slightly milky. |
| Smell at 100° F. | None. | None. | None. | Weedy. | Slightly weedy |
| Chlorine in chlorides | 2·093 grs. | 2·124 grs. | 2·215 grs. | 2·1700 grs. | 2·2400 grs. |
| Nitrogen in nitrates | ,, | ,, | ,, | 0·0299 ,, | 0·0311 ,, |
| Phosphoric acid in phosphates. | ,, | ,, | ,, | — | — |
| Ammonia | None. | None. | 0·005 grs. | 0·0056 grs. | 0·0042 grs. |
| Albuminoid ammonia | 0·002 grs. | 0·001 grs. | 0·003 ,, | 0·0028 ,, | 0·0028 ,, |
| Oxygen absorbed [at 80° F. in 15 minutes. | 0·001 ,, | 0·002 ,, | 0·003 ,, | 0·0094 ,, | Not got. |
| Oxygen absorbed at 80° F. in 4 hours. | 0·009 ,, | 0·006 ,, | 0·014 ,, | 0·0126 ,, | 0·0138 grs. |
| Total solid matter dried at 220° F. | 34·400 grs. | 34·200 grs. | 34·900 grs. | 32·0000 grs. | 33·0000 grs. |
| Lead and other poisonous metals. | None. | None. | None. | — | — |
| | Water taken from tap at George Street. | Water taken from tap at George Street. | Water taken from tank. | Water taken from tap at George Street. | Water taken from tank. |

Sample (*a.*) Microscopical examination satisfactory.

This water is very free from indications of organic impurity. I am of opinion that it is a good water for drinking. The amount of total solid matter in solution is somewhat large, and it will, therefore, be somewhat "hard."

Sample (*b.*) Microscopical examination revealed a few specimens of diatomaceæ and infusoria common to most waters. No indications of bacteria or morbid products.

This is a good water for drinking purposes, being very free from organic impurities.

Sample (*c.*) Microscopical examination satisfactory.

This water is very free from organic contamination, and quite suitable for drinking purposes.

---

Sample (*d.*) Microscopical examination.—Moving organisms, including algæ, bacteria, paramecia, annelids, &c.; domestic fibres, starch granules, &c., &c.

The analysis is fairly satisfactory from a chemical point of view, with the exception of the ammonia, which, in my opinion, is evidence of sewage pollution of recent date.

The microscopical examination, which has been made with scrupulous care, shows that the water possesses highly objectionable features. The presence, for instance, of dyed cloth fibres and starch granules, which proved to be granules of arrowroot starch, is exceedingly suggestive of contamination with household refuse.

I have no hesitation in saying that such water as this is unfit for public consumption, and is a source of danger to public health.

Sample (*e.*) Microscopical examination.—Starch granules (bean, oat, and barley or wheat), fungoid growths, moving organisms (various), vegetable *débris*, broken hairs, paper, and other domestic fibres.

This water is not satisfactory as a drinking water. I consider the ammonia to be evidence of recent sewage pollution. I take this item in connexion with the microscopical examination, which is of sufficiently suggestive character. I am distinctly of opinion that, unless a very satisfactory explanation of the presence of the ammonia to which I allude is forthcoming, the water cannot be considered a safe water for public supply.

I speak solely from analytical results. I have no knowledge whatever of the origin of the sample, and I give my opinion apart from any outside consideration, as I am clearly bound to do.

## ADDENDUM No. II.

Sample contained in a Winchester quart bottle, stoppered. Bottle labelled:—

"Water from Reservoir at New Herrington."

The water is slightly turbid, and on standing yields a trace of deposit consisting chiefly of mineral matters but containing various fungoid growths and a few animalculæ. It is hard, but becomes moderately soft on boiling.

The presence of ammonia and the somewhat high proportion of albuminoid ammonia yielded indicate some pollution, which, however, appears to be, mainly at least, of a vegetable character.

The water is decidedly less pure than the sample of water examined for the Houghton-le-Spring Union Sanitary Authority in 1885 and reported upon on September 22nd, 1885. It would therefore be advisable to examine the reservoir as well as the sources of supply, with a view of discovering and, if necessary, removing any source of pollution.

| | |
|---|---|
| Appearance | Slightly turbid. |
| Colour | Pale brownish. |
| Smell | Inodorous. |
| Deposit | Minute trace. |
| Nitrous acid | None. |
| Phosphoric acid | Scarcely perceptible trace. |
| Poisonous metals | None. |
| Hardness before boiling | 22·0°, Clark. |
| ,, after ,, | 8·5°, Clark. |

| | Grains per Gallon. |
|---|---|
| Oxygen absorbed from permanganate | 0·013 |
| Total dry residue | 34·44 |
| Colour of residue | Pale brownish. |
| Behaviour of residue on ignition | Chars very slightly; burns off readily. |
| Chlorine | 2·1 |
| Nitric acid | 0·035 |
| Ammonia | 0·0092 |
| Albuminoid ammonia | 0·0039 |

(Signed) A. Dupré.

Laboratory,
Westminster Hospital Medical School,
Caxton Street, Westminster, S.W.

May 16th, 1889.

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## ADDENDUM No. III.

Laboratory and Assay Office,
75, The Side, Newcastle-on-Tyne,
May 25th, 1889.

I hereby certify that I have analysed the under-mentioned sample of water, and that I find the following results per gallon :—

Sample marked "From Boiling well" contains—

| | |
|---|---|
| Total solid matter in solution - - | 33·800 grains. |
| Chlorine existing as chlorides - - | 1·699 ,, |
| Ammonia - - - - | Trace. |
| Albuminoid ammonia - - - | 0·001 grains. |
| Oxygen absorbed in 15 minutes - | None. |
| Do. in 4 hours - - | 0·03 grains. |
| Lead and other poisonous metals - | None. |
| Appearance in 2-foot tube - - | Clear and colourless. |
| Smell when heated to 100° Fahr. - | None. |
| Microscopical examination - - | Satisfactory. |

This water is very free from indications of organic impurity. I am of opinion that it is quite suitable for drinking.

(Signed) John Pattinson.

## No. 9.

Extracts from a Report on "Diphtheria" in the Halstead Registration District, illustrative of the Nomenclature of Throat Diseases; by Dr. Bruce Low.

The Halstead Registration District is situated in North Essex; it comprises 39,239 acres, and had, at the last census, a population of 17,004 persons.

Diphtheria has for a series of years persisted in the Halstead Registration District, as also in neighbouring districts in Essex, Suffolk, and Cambridgeshire. Of late the mortality from this disease has shown a tendency to increase rather than diminish in the Halstead Registration District, as will be seen from the subjoined table.

Table I.—Showing Deaths registered from Diphtheria during each of the 15 Years 1874 to 1888 in the Halstead Registration District.

| —— | 1874. | 1875. | 1876. | 1877. | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Halstead Registration District. Population (1881) 17,004 | 1 | 2 | 2 | 1 | 2 | — | 1 | 1 | 1 | 6 | 17 | 6 | 4 | 8 | 11 | 63 |

It was the above recent increased mortality from diphtheria into which I was directed to make inquiry. As a preliminary to this it became necessary to ascertain what had been the localities of its chief prevalence. For this purpose I made a careful examination of the death records of the Registration District during the last 15 years; and it soon became evident that "Diphtheria" as a registered cause of death was not alone in question. In these records there were, concurrently with the deaths registered as due to diphtheria, many deaths registered from croup, laryngitis, tracheitis, and the like. Not only were these deaths concurrent in point of time with the diphtheria deaths, increasing and decreasing in number throughout the 15 years with increase or decrease of diphtheria deaths, but they were concurrent in the same localities, in town and country, and concurrent often in the same families and houses, especially in recent years. The following are some illustrations of this.

In the month of January a few years ago five deaths were certified from "Diphtheria" in a small village. During the same month in the adjoining parish two deaths occurred within five days of each other; both were certified as being from "Tracheitis," and 16 days later a third death took place, this being certified from "Croup." In another village near, two deaths took place from "Diphtheria," one in September, and the other in November of the same year. Four weeks later three deaths (two in persons of the same name) occurred in one day in this village, all three being certified as from "Tracheitis," two of them having "collapse" added as a secondary cause. In a different village, seven deaths from throat ailments were registered in one year, three of them from "Laryngitis," two from

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"Diphtheria," one from "Diphtheritic Laryngitis," and one from "Croup." In another locality two deaths happened in one house, within six days of each other, the first being certified "Membranous Croup" and the second "Diphtheria." Elsewhere a child aged six died of "Ulcerated throat, Syncope." On the day of her death her mother was seen to kiss frequently her dying child's lips. Three weeks later her mother died, her death being certified from "Diphtheria." After her death two younger children became ill with throat ailment, as also did a relative who came to nurse the mother. The baby, aged eight months, died four weeks after its mother, the death being certified from "Croup."

From a study of these death records and from other evidence it became apparent that, in the Halstead Registration District, diphtheria, and especially non-fatal diphtheria, had gone under various different names, and that the deaths registered under the heading of Diphtheria, by no means truthfully represented the dimensions of the mortality from what had been essentially one and the same disease.

Table II. shows this mortality for each of the 15 years 1874 to 1888, and Table III., dealing with the same figures in quinquennial periods, displays the magnitude of the recent increase of fatal throat illness in this Registration District. It also at the same time shows that throughout the period under consideration, the deaths ascribed to diphtheria have represented *less than one-half of the mortality* that probably may fairly be referred to that disease.

Table II.—Showing for the Halstead Registration District the Deaths referred to Diphtheria, Croup, Laryngitis, Tracheitis, and Tonsilitis, in each of the 15 Years 1874 to 1888.

| | 1874. | 1875. | 1876. | 1877. | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diphtheria - - | 1 | 2 | 2 | 1 | 2 | — | 1 | 1 | 1 | 6 | 18 | 5 | 4 | 8 | 11 | 63 |
| Croup - - - | 3 | 2 | 4 | 8 | — | — | 2 | 1 | 2 | 6 | 13 | 8 | 3 | 7 | 7 | 66 |
| Laryngitis - - | — | — | 1 | 1 | — | 1 | — | — | — | 1 | 3 | 2 | 3 | 4 | — | 16 |
| Tracheitis - - | — | — | — | — | — | — | — | — | — | — | 5 | — | 1 | | — | 7 |
| Tonsilitis and ulcerated throat. | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | 1 | 2 |
| | 4 | 4 | 7 | 10 | 2 | 2 | 3 | 2 | 3 | 13 | 39 | 15 | 11 | 20 | 19 | 54 |

Table III.—Showing for Halstead Registration District the Deaths referred to Diphtheria and the above-named diseases in each of the successive Quinquennial Periods, 1874 to 1888.

| | 1874-78. | 1879-83. | 1884-88. | Total. |
|---|---|---|---|---|
| Diphtheria - - - | 8 | 9 | 46 | 63 |
| Croup - - - | 17 | 11 | 38 | 66 |
| Laryngitis - - - | 2 | 2 | 12 | 16 |
| Tracheitis - - - | — | — | 7 | 7 |
| Tonsilitis and ulcerated throat - | — | 1 | 1 | 2 |
| | 27 | 23 | 104 | 154 |

As with diphtheria, so with the several throat diseases included in the above tables, the mortality has been chiefly among children. This will be seen from Table IV. subjoined, which gives the mortality at each of several age-periods from diphtheria and the other throat maladies collectively. Table V. is added with the purpose of showing roughly the death-rates from these diseases at each age in three successive quinquennial periods from 1874 to 1888; the numbers of persons living at each age at the census of 1881 being taken as the bases for calculation.

Table IV.—Showing the Deaths at certain Age-Periods from Diphtheria and allied Throat Affections in the Halstead Registration District, during 15 Years 1874 to 1888.

| Age-Periods. | 1874. | 1875. | 1876. | 1877. | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. | Total in 15 years. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Under 1 year - | 1 | — | — | 3 | — | 1 | — | — | — | — | 3 | 2 | 1 | — | 2 | 13 |
| 1 to 5 years - | 1 | 2 | 6 | 5 | — | — | 3 | — | 2 | 8 | 17 | 8 | 7 | 11 | 11 | 81 |
| 5 to 15 years - | 1 | 1 | 1 | 2 | 2 | — | — | 2 | 1 | 5 | 18 | 5 | 3 | 8 | 4 | 53 |
| 15 to 25 years - | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | 2 | 3 |
| 25 to 60 years - | 1 | 1 | — | — | — | 1 | — | — | — | — | — | — | — | 1 | — | 4 |
| Totals - - | 4 | 4 | 7 | 10 | 2 | 2 | 3 | 2 | 3 | 13 | 39 | 15 | 11 | 20 | 19 | 154 |

Table V.—Giving Death-Rates, per 1,000 living, at various Ages, from Diphtheria, and Throat Affections, in the Halstead Registration District, for each of the three Quinquennial Periods, 1874 to 1878, 1879 to 1883, and 1884 to 1888.

| Age-Periods. | Number of Persons living at different Ages (in 1881). | Quinquennial Periods:—Death-Rates from Diphtheria and Throat Affections per 1,000 living at each Age. | | |
|---|---|---|---|---|
| | | 1874-78. | 1879-83. | 1884-88. |
| 0 to 1 year - - - | 390 | 10·2 | 2·5 | 20·5 |
| 1 to 5 years - - - | 1,631 | 8·5 | 7·9 | 33·1 |
| 5 to 15 years - - - | 4,131 | 1·6 | 1·9 | 9·1 |
| 15 to 25 years - - - | 2,882 | 0·0 | 0·0 | 1·0 |
| 25 to 60 years - - - | 6,127 | 0·3 | 0·1 | 0·1 |
| 60 and upwards - - | 1,844 | 0·0 | 0·0 | 0·0 |
| All ages - - - | 17,004 | 1·5 | 1·3 | 6·1 |

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Passing now to the localisation of fatal throat illness within the Halstead Registration District during the last 15 years, an examination of the death records was made with a view to ascertain the number of deaths, year by year, from diphtheria and allied diseases in Urban Halstead, and in each of the several parishes constituting the Rural Sanitary District. The facts obtained are given in Table VI. (*not here produced*).

A glance at this table shows that, taking one year with another, fatal throat illness had been widely distributed over the whole Registration District, but that certain localities, as for example, Halstead town and the village of Sible Hedingham, had suffered much more heavily as regards this mortality than other places in the District. The question to be answered, therefore, was this: had the exceptional mortality experienced in the above-mentioned places been due to greater prevalence of diphtheria and allied throat illness; or had it arisen through greater fatality therein, of disease which had been tolerably uniformly distributed over the whole District?

When local inquiries were made it speedily became clear that no definite answer could be given to the above question, chiefly for the reason that there was great difficulty in defining "prevalence" of diphtheria. It was found that as with the fatal throat illness of previous years, so also with the same kind of disorder fatal and non-fatal in more recent times, a good deal of it had not been recognised as bearing any relationship to diphtheria; the consequences being that the commencement and gradual development of not a few ultimately serious diphtheria "prevalences" had escaped notice; while other considerable, although less fatal, outbreaks of what was substantially the same complaint, had gone undetected from start to finish.

The history of a "diphtheria prevalence", *accepted as such* in this District, when it came to be pieced together would commonly be this.

After, or during, a prevalence in a given locality for a shorter or a longer period of sore throat—to all appearances trivial in character, exciting little or no attention, and seldom coming under medical treatment—there would occur scattered cases or groups of cases of throat affection of sufficient severity to keep older children from school; in younger children this illness would now and then assume what the parents and friends would consider a "croupy" tendency, As a rule the "croupy" cases would not come under medical observation, the fatal issue generally following quickly the onset of the ailment. The result of this has been that these deaths would have been registered as "Croup." Sooner or later the throat malady still persisting in the same locality, and children of school-going ages beginning now to suffer from fatal attacks, the term "Diphtheria" would probably be used occasionally in the death register, but even under such circumstances, the deaths of school-going children might, like deaths in their younger brothers and sisters, be registered for a time as "Croup" or some synonym of it. Multiple deaths, however, from throat disorder among school children, would have usually brought about a change in the local nomenclature of the prevalent malady; and along with this a recognition of the serious significance at least of the later manifestations of the disease. Diphtheria prevalences running this course, and in this manner forcing themselves on attention, have been sufficiently frequent in the district.—As to others, I have myself by the assistance of death registers and school log-books, come upon prevalences of throat illness (precisely similar in all respects to the foregoing, with the exception of the multiple deaths of school-going children) as to which no mention is made of the term diphtheria in local records, official or non-official. In

other ways, too, I have been led to believe that the list of outbreaks in this District, even for recent years, is not yet by any means complete. In illustration of what has just been said, I give the following examples from my note-book.

At a village where, up to 1887, there had not been any known cases of diphtheria for at least six years, I was informed by the lady who owns the place that sore throats had of late become very prevalent. In her own large household there had been numerous cases, and in her visits to the village she heard of other cases among the cottagers and among the school children. During 1887, seven of her servants had suffered from such an affection, one after the other; and in each case the throat illness was followed by prolonged prostration. There was a good deal of intercommunication between her servants and the villagers. On the 22nd of August in the same year, a child, aged two, died of "Croup" in the village. Towards the end of this month the school re-opened after the harvest holidays, and the teacher soon observed that sore throat became rife among the scholars. On the 17th of October the log-book states that 17 children were absent from this cause. On the 24th of October a child, aged five, who had been attending school, died after a few days' illness: her death was registered as due to diphtheria. About a fortnight later a woman, aged 29, the mother of two children who had been away from school with sore throat, died, and her death was also certified as resulting from diphtheria. During November the assistant schoolmistress was absent from school for eight days; her illness was said to have been quinsy. There can be little doubt now that the sore throat previously so prevalent was a form of the same disease, which, when fatal, was called croup at first, and then diphtheria; and most probably the quinsy of the schoolmistress was likewise a form of diphtheria, contracted in school.

In another village in which no known cases of diphtheria had occurred since 1883 (when only one fatal case was reported), there occurred in the early part of 1887 a number of cases of severe sore throat. Three deaths resulted, and were certified in each case as "Croup," the ages of the victims being respectively two, five, and seven years. The first ascertained case of sore throat in the village was a school-girl, aged five. She recovered, but her articulation was so impaired that for two months her family could scarcely make out the words she tried to speak. She had no medical attendance. At the beginning of her illness another girl, aged five, visited her sick schoolfellow on several occasions. She also was taken ill, and after six days' illness died, the death being registered as from "Croup." About this time other children in the village were suffering from bad throats, and a month subsequent to the little girl's death a boy, aged seven, died after a short illness; his death was likewise certified as "Croup." (Two of his brothers were ill with sore throats not long after.) Later on another death occurred, and it also was registered as resulting from "Croup." Altogether I heard of 18 cases of throat illness (including these three deaths) in this village, but there must have been others of which I heard nothing, since most of the cases I met with were lighted upon almost accidentally. In two at least of the fatal "Croup" cases there was evidence of the illness being of an infectious nature. The result of my inquiries led me to believe that this outbreak of throat illness was in reality diphtheritic, although it had not been locally recognised as such at the time.

It became, in fact, plain that, in reference to the question "What had been diphtheria prevalence?" sore throat would demand consideration. Not only the "sore throat" which had preceded or accompanied more or less undisputed diphtheria, but "sore throat," much of which had existed independently of recognised specifically infective illness.

It transpired, as a result of my inquiries, that sore throat had been very plentiful for many years, and that it had not been altogether limited

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to children. It appeared indeed very possible that sore throat had been ubiquitous throughout the District. Locally, this ailment had gone under a variety of names—"congested sore throat," "tonsilitis," "rheumatic sore throat," "follicular tonsilitis," "Halstead sore throat," and the like. And as a rule, there does not seem to have been suspicion that this sore throat was related in any way to true diphtheria.

One non-medical informant, whose statements I have every reason to believe are made with considerable knowledge of a particular part of the district, says that there has been for some years there an extraordinary prevalence of bad throats. The usual characters of this ailment have been soreness of the throat, attended sometimes by ulceration of the tonsils, lasting generally about a fortnight, but followed by a considerable period afterwards by extreme prostration and weakness. My informant goes on to say the local doctors call it "Halstead sore throat," and adds, "declared diphtheria cases have been few."

One medical practitioner says he often meets with groups of cases of "follicular tonsilitis," evidently related to each other, but not, in his opinion, diphtheritic. Another local surgeon says "congested throat" is of common occurrence in his practice at all times, but he has not hitherto looked upon it as connected with the outbursts of diphtheria. Another gentleman says that 25 per cent. of the children he sees in his practice have something wrong with their tonsils or fauces. Medical testimony generally is to the effect that in families attacked with unmistakeable diphtheria, cases of sore throat are often found, especially in adults, and that, so far as can be seen, these sore throats present only an appearance of redness and tumidity of the tonsils. And it is admitted that in the absence of diphtheria in the family, such throats would be regarded as the results of ordinary chill, causing congestion or catarrh, and not as being specifically infective. Therefore, without asserting that all throat illness included under the various terms given above, has been substantially diphtheria, it is impossible to deny that much of it was in all probability of that nature. Accordingly, the difficulty in defining what localities, if any, have been exempt from diphtheria, was found insurmountable. Under the circumstances, it would have been useless to have attempted to trace out the beginnings of the several local outbreaks; all that was possible has been an attempt to identify the chief conditions under which diphtheria has manifested itself in a District where sore throat may be regarded as endemic, if not as universally prevalent.

Inquiries made in this direction elicited a familiar story—namely, that personal communication had been a powerful agent in developing diphtheria outbreaks. This is precisely what might have been expected in a district where at least nine-tenths of the current sore throat, and fully one-half of what was really diphtheria, had been dealt with as of no concern to anyone but the subject of the maladies in question. Only when the term "diphtheria" came into use, regarding a particular case or group of cases, had any precautions been observed of a kind to stay the spread of "infectious disease." Consequently the effects of personal communication in conveying diphtheria in the District are perhaps best illustrated on a large scale, such as is afforded by school influence, factory influence, and the influence arising through frequent business communication of one locality with another.

[*The report goes on to consider these questions in detail.*—G. B.]

## No. 10.



Extract from a Report on the Fatality from "Croup," and other Throat Affections, in the Horwich Registration Sub-District, illustrative of the Nomenclature of Throat Diseases; by Mr. John Spear.

This sub-district comprises the two urban sanitary districts of Horwich and Westhoughton, and one parish (Lostock) of the Bolton Rural Sanitary District. During the fourth quarter of 1887 and in 1888, a notable increase in the deaths from *diphtheria* was recorded by the Registrar-General, so that the attention of the Board was directed to the matter. It appeared, however, upon my visit to the district, that the majority of the deaths so classified had not been specifically registered, although afterwards recorded, under that head, but that most of them had been certified under the name of *croup*.* It likewise appeared that an unusual number of deaths had been registered from "tracheitis" (a name used by one medical man at least in the district as a synonym of "croup") and "laryngitis," and it was obvious that such cases would have to be taken into account for the purpose of my investigation.

The relative prevalence of these fatal throat affections during recent years, the distribution in the three sanitary divisions of the registration sub-district, and the exact local nomenclature, are shown in the table subjoined:—

| Period. | Registration Sub-District. Total. | Horwich Urban Sanitary District. Population (1881) 3,761; estimated (1888) 11,000. | | | | Westhoughton Urban Sanitary District. Population (1881) 9,197; estimated (1888) 10,400. | | | | Lostock Parish (Bolton R.S.D.). Population (1881) 782; estimated (1888) 800. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Diphtheria. | Croup. | Tracheitis and Cynanche Trachealis. | Laryngitis. | Diphtheria. | Croup. | Tracheitis and Cynanche Trachealis. | Laryngitis. | Diphtheria. | Croup. | Tracheitis. | Laryngitis. |
| 1884 | 3 | — | — | — | 1 | — | 1 | — | — | — | — | 1 | — |
| 1885 | 4 | 1 | 1 | — | — | — | 1 | — | 1 | — | — | — | — |
| 1886 | 6 | — | — | — | 3 | 1 | 1 | — | 1 | — | — | — | — |
| 1887 | 13 | — | — | 1 | — | — | 8 | 3 | 1 | — | — | — | — |
| 1888 | 27 | 1 | 3 | 4 | 3 | 3 | 10 | — | 1 | — | 2 | — | — |
| 1889 (First Quarter.) | 4 | — | — | — | 1 | 2 | — | — | 1 | — | — | — | — |
| Total - - | 57 | 2 | 4 | 5 | 8 | 6 | 21 | 3 | 5 | — | 2 | 1 | — |

* The names "croup" and "diphtheria" would appear to have been accepted by the Registrar-General as synonyms for the purposes of his quarterly returns. The diseases otherwise named would appear not to have been included in his quarterly "diphtheria" columns.

App. A. No. 10.

On "croup" and other throat affections in the Horwich Registration Sub-District; by Mr. Spear.

Exact clinical histories in these cases of "croup," tracheitis, and laryngitis, were found to be very meagre. With one exception, the subjects were all young children, and in the majority of cases medical attendance was only obtained a few hours before the fatal termination. In three cases of "croup," membrane is said to have been visible, either on the pharynx or on expectoration; laryngoscopic examination, so far as I could ascertain, was not made; nor was albuminuria sought for. In the more obvious general symptomatology little differentiation was found possible between these fatal affections, whether described as croup, tracheitis, or laryngitis. In most of the cases there was a history of malaise for some few days before medical aid was obtained, the child being commonly supposed to be suffering from "a cold." At this time headache, sometimes pains in the back and limbs, slight sore throat, and lassitude are chiefly spoken of. In a considerable proportion of cases swelling of the lymphatic glands or infiltration of the soft parts around the neck and throat externally were visible during the later stage of the illness, and in a few cases during the premonitory stage. Rapid discolouration of the skin of the throat and neck after death was several times remarked; but beyond this no *post-mortem* observation had been made. Upon the premonitory malaise spoken of above, a condition of asthenia supervened, asphyxia then rapidly developing and proving fatal.

In 34 of the 38 fatal cases of croup, tracheitis, and laryngitis, registered as occurring during the last $2\frac{1}{4}$ years (*i.e.*, since the increased fatality is recorded), the duration of the illness, dating from first sign of indisposition, was stated as follows:—One day, 1; two days, 7; three days, 9; four days, 5; five days, 2; seven days 4; nine or ten days, 2: in two cases the child had been ailing for two weeks, and in two for three weeks before the fatal termination. Some 80 per cent. received medical treatment only within the last 24 hours, and many of these were seen just before death. The disease, in fact, excited, as a rule, little attention until just before the end.

The record of such non-fatal cases of this illness as were reported, afforded little assistance in an inquiry as to the exact nature of the disease. There were, indeed, few such cases; and these rarely in the same neighbourhood or apparently associated with the fatal attacks. In some half-dozen, the history was that of diphtheria, but on the whole the testimony available from this source suggested that under the name of croup or tracheitis diseases of different etiology had been included, and the same observation applies to attacks ascribed to "laryngitis."

Referring again to the fatal cases, those that have occurred within the last $2\frac{1}{4}$ years may be classified according to the age of the sufferers as follows: I have included in one column those ascribed to "croup," "tracheitis," and "laryngitis" (regarding them as a whole as from ill-defined causes); the deaths specifically referred by the medical certificate to diphtheria are included in the lower column of the table.

| Deaths registered from | Total. | Under 1. | 1–3. | 3–5. | 5–7. | 14 years. | Above 14 years. |
|---|---|---|---|---|---|---|---|
| Croup, tracheitis, and laryngitis. | 38 | 1 | 20 | 13 | 3 | 1 | — |
| Diphtheria - - - | 6 | — | 2 | 2 | — | — | 1, 17 years.<br>1, 34 years. |

The distribution of these fatal cases, as to time and place, is shown in the subjoined table :—

| District. | Period. | Disease. | Total. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Horwich U.S.D. | 1887 | Croup, laryngitis, &c. | 1 | — | — | — | — | — | — | — | — | — | — | — | 1 |
| | | Diphtheria | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | 1888 | Croup, &c. | 10 | 2 | 1 | 1 | — | 1 | — | — | — | 2 | 2 | 1 | — |
| | | Diphtheria | 1 | 1 | — | — | — | — | — | — | — | — | — | — | — |
| | 1st Qr. 1889. | Croup, &c. | 1 | 1 | — | — | | | | | | | | | |
| | | Diphtheria | — | — | — | — | | | | | | | | | |
| Westhoughton U.S.D. | 1887 | Croup, &c. | 12 | 2 | 1 | 1 | — | — | — | — | — | 4 | 1 | 2 | 1 |
| | | Diphtheria | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | 1888 | Croup, &c. | 11 | 1 | — | 3 | 1 | — | — | — | 2 | — | 2 | 1 | 1 |
| | | Diphtheria | 3 | — | — | — | — | — | — | — | 1 | 1 | — | — | 1 |
| | 1st Qr. 1889. | Croup, &c. | 1 | — | — | 1 | | | | | | | | | |
| | | Diphtheria | 2 | 1 | 1 | — | | | | | | | | | |
| *Lostock parish | 1888 | Croup | 2 | — | — | — | — | — | — | 1 | — | — | — | 1 | — |
| Whole district | 2¼ years | Croup, tracheitis, laryngitis. | 38 | 6 | 2 | 6 | 1 | 1 | — | 1 | 2 | 6 | 5 | 5 | 3 |
| | | Diphtheria | 6 | 2 | 1 | — | — | — | — | — | 1 | 1 | — | — | 1 |
| | | Total | 44 | 8 | 3 | 6 | 1 | 1 | — | 1 | 3 | 7 | 5 | 5 | 4 |

* No death was registered from diphtheria in this part of the district, nor from croup or laryngitis during 1887 or the first quarter of 1889.

Except for the broad fact that Westhoughton was affected considerably earlier than the Horwich district no very noticeable incidence of the disease either as to time or place is apparent from this classification. As to family invasions, the main facts in connexion therewith may be thus stated. The 38 fatalities ascribed to "croup, tracheitis, and laryngitis" occurred in 35 different households. In 26 of these no other attack of any similar nature (either of croup, laryngitis, diphtheria, or noticeable sore throat), so far as could be discovered, had occurred, although there were living in these 26 households some 78 other children or young people. In the remaining nine households secondary cases occurred as follows :—

1. February 1887.—Child, aged 4, died from "laryngitis;" four other children of the family suffered about the same time from more or less severe sore throat (no subsequent paralytic symptoms observed).
2. March 1887.—Child suffered from bad sore throat; brother seized few days later and died from "laryngitis."
3. September 1887.—Children of same family, aged respectively 3 and 1½ years, died within two days of each other from "laryngitis."*
4. November 1887.—One child, aged 3, died from "laryngitis"; another, aged 4, suffered in following week from "croup."

* These two children were both convalescing from measles, and a week earlier a child living in an adjoining house had died of that disease.

5. January 18th, 1888.—Boy, aged 14, died from "laryngitis"; three children of the same family suffered a few days later with similar symptoms.*
6. January 8th, 1888.—Child, aged 3, died from "diphtheria," the case being, I was informed by the medical man, quite typical; a sister, aged 2, died on February 25th from what was certified by another practitioner as "croup."†
7. January 12th, 1888.—Child, aged 3, died from "croup"; another, of same family, aged 2, suffered from similar symptoms four days later.‡
8. March 11th, 1888.—Child, aged 2, died from "croup"; another, of same family, aged 5, died on 5th October following, the death being ascribed to the same cause.
9. August 13th, 1888.—Child, aged 3 years, died from what was registered as "croup"; a week later the mother sickened and died on August 25th of "diphtheria"; the grandmother also who had assisted in nursing the child suffered from sore throat.

Of the six fatal cases of *diphtheria*, three were single ones (*i.e.*, there was no other case either of diphtheria, croup, &c., in the families invaded). Two others occurred in houses where deaths from "croup" also were recorded (cases 6 and 9 above), and the remaining one was associated with two mild attacks in the family invaded, and, probably, with two or three elsewhere. Unlike most of the cases of "croup," there was in certain of these cases of diphtheria some presumptive evidence of the spread of the disease by personal intercourse between the sufferers.

The above record includes all the cases in which multiple attacks of what could be regarded either as diphtheria or "croup" occurred, but there were several others in which attacks of measles and a few in which attacks of scarlatina were coincident with fatal cases recorded as "croup" or "laryngitis." This was specially noticeable at Westhoughton, where between September 19th and November 30th, 1887, measles prevailed so extensively that no less than 21 deaths from that cause were recorded. Between March 9th and September 26th of that year no death at Westhoughton from any of the throat affections in question was registered; and then in the next four days, four deaths from "croup" or "laryngitis" occurred in families in which, immediately before, or at the time, measles prevailed. The coincidence, it seems to me, is scarcely to be regarded as accidental.

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* This family, consisting of five persons, occupied an isolated farm house near Westhoughton. The boy was not known to have been exposed to risk of any infection; he sickened on January 14th, 1888, with headache, dizziness, sore throat, and quickly succeeding prostration. He died on the 18th, the throat symptoms becoming the most prominent, so that the death was certified as from "laryngitis." Within about a week three other young people at the house developed somewhat similar, although less severe, symptoms. Dizziness appears to have been chiefly complained of and slight sore throat; a mottled appearance of the skin, somewhat resembling urticaria, except that there was no elevation of the whitish patches, is likewise spoken of. No subsequent desquamation of the cuticle occurred, nor could I ascertain that there had been any symptom of paralysis. Twelve cows were kept on the farm at the time, the milk being chiefly used, except for a small quantity consumed by the family, in butter making; and the farmer states that shortly before and at the time of his children's illness three of the cows suffered from some feverish attack with "bad colds." No sores on the teats were observed.

† This family lived at Horwich; the second child had been sent from home on the sister's seizure, and had only returned three days when she herself sickened. Clearly developed membrane and albuminuria are spoken of as distinguishing the first attack.

‡ The two children (residing at Horwich likewise) had been accustomed to play near an open sewage gutter.

No. 11.





Report on an Epidemic of Scarlatina in the Faringdon Rural Sanitary District, and upon the Sanitary Administration of that District; by Mr. John Spear.

This district covers an area of some 63,000 acres, and at the time of the last census contained a population of 13,676. It extends into three counties, Berkshire, Oxfordshire, and Gloucestershire; and, geologically, from south to north, it lies successively upon the Chalk, the upper and lower greensand, and the oolitic groups.

The epidemic of scarlatina was confined to the central and largest parish, that of Faringdon, although a few scattered cases occurred in outlying places. It appears that the disease had been prevalent at Wantage, in a neighbouring district, and in May 1888, a girl in service near that town was removed, while suffering from scarlatina, to her home at Pasey, in the Faringdon Rural District. The children of two families belonging to the adjacent village of Buckland were soon afterwards attacked. Between these places and Faringdon there is frequent communication, and the father in the case of one of the two families last named is said to have visited the town regularly in pursuit of his occupation.

The first case at Faringdon cannot, however, be clearly identified. Measles had been very prevalent during the spring; many of the sufferers had received no medical aid, and I heard of cases in three different families in which definite desquamation of the cuticle had followed supposed attacks of measles. The first recognised case of scarlatina in Faringdon occurred towards the middle of June, in the person of a man, two of whose children had a fortnight or so before been the subjects of equivocal attacks of this kind. The progress of the epidemic thenceforward may be shown in tabular form as follows:—

| In Faringdon Parish. | Total. | 1888. | | | | | | | 1889. |
|---|---|---|---|---|---|---|---|---|---|
| | | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jany. |
| Family invasions | 46 | 2 | 7 | 10 | 8 | 4 | 12 | 2 | 1 |
| Cases - - | 77 | 2 | 18 | 15 | 13 | 8 | 17 | 3 | 1 |
| Deaths (classified according to the commencement of the attack). | 28 | — | 11 | 5 | 5 | 1 | 6 | — | — |

The disease occurred chiefly amongst young children, between the ages of two and eight years; four infants, just below the age of one year, contrary to common experience, died. Of the 77 attacks recorded above, only seven were amongst persons above the age of 14 years, and they were free from fatality. In three or four cases I heard of attacks

of slight sore-throat with general malaise amongst persons much exposed to infection.

The fatality of the developed cases was it will be seen enormous. Of the total number, 36 per cent. proved fatal; and during the first month of the epidemic a little more than half of those attacked died. In a large majority of these cases the throat seems to have been early and most seriously involved, although in a certain number death occurred so speedily, and with symptoms of such profound general infection that the term malignant might properly be used to designate the type of the disease.*

The history of scarlatina in the district during recent years appears to have been until the last epidemic quite uneventful. In 1884 the Medical Officer of Health reported a "slight epidemic of scarlatina and measles in the town [Faringdon] and villages," and one death from scarlatina and one from diphtheria were then recorded in Faringdon. In 1885, scarlatina is again spoken of as prevailing in the town and villages; during the year no death was registered from this cause in Faringdon town, but in the adjacent villages of Eaton Hastings on one side, and Great Coxwell on another, there were as many as seven deaths. In 1886 a single case is recorded as occurring in Faringdon town, and from that time, till the outbreak in June 1888, the district appears to have been clear from the disease.

The time at my disposal did not permit any complete investigation of the cause or causes of the excessive virulence displayed in this latest outbreak. It has to be noted, and the coincidence has several times, in other places, been observed, that measles prevalence preceded the scarlatina epidemic. I am unable to make any critical analysis of the several family outbreaks for the reason just stated, but it seemed to me that a considerable proportion of the families infected from the one disease had shortly before suffered from the other. Another zymotic, chicken-pox, had likewise to some extent prevailed, and this concurrence, again, I have before remarked. In a family in Faringdon in which, between July 12th and August 8th, six children died from scarlatina, two of the children had shortly before suffered from chicken-pox.

The pre-existence of zymotic disease may, it is conceivable, in some way lead to the more effective operation of the scarlatinal poison; or, of course, it may be mere coincidence determined by the presence of conditions favourable in common to several specific contagia. In this connexion it has to be remarked that the sanitary circumstances under which the people of Faringdon were living were frequently, and in many important respects, unsatisfactory. At the house just referred to, where six fatal cases occurred, I found for example the following conditions: The water supply was derived from a well sunk in the yard of the house, and in the same yard was a deep cesspool into which the closet discharged; the drainage was imperfect, and it had been noticed that rats had occasionally invaded the house. Immediately outside the kitchen door was an untrapped drain gully; beneath the basement of the house a drain, constructed without any of the precautions proper to

* It is improbable that undeveloped or unrecognised cases could have been sufficiently numerous to materially modify this testimony. At the beginning of the outbreak it is possible that a few cases may have been mistaken for measles that had just before prevailed, but the disease soon excited much attention from its great fatality. Medical aid was then promptly secured, and the progress of this epidemic keenly noted.

be taken in such cases, passed to the imperfectly ventilated sewer in the street, and in the cellar there was a gully with direct drain communication. The bedrooms were small and overcrowded.

The disease spread, it would seem, by personal intercourse, and I could find no evidence implicating other media. The outbreak found the Sanitary Authority wholly unprepared to meet such an emergency, for no hospital for isolation, or proper apparatus for disinfection, had been provided. I heard of convalescents from the disease moving about in public places (one, for example, presented himself while desquamation was still going on at a doctor's crowded surgery); shops attached to infected houses remained open, and people engaged at night in nursing the sick followed by day their usual occupation. The disease spread amongst neighbours and friends and relations, and, while the schools were open, amongst school companions.

At first the Authority were content to "supply disinfectants"; and the Inspector of Nuisances tells me that he spilt much carbolic acid about infected premises, having a watering-can for that purpose. Then, on the 20th of September (nearly three months after the recognized appearance of the disease), the children's detached wards at the workhouse were, by arrangement with the Guardians, utilized as isolation wards, the children being removed to the body of the house. Eight sufferers were thus isolated during the succeeding week, the people in the town availing themselves willingly, now and afterwards, of the proffered accommodation, and there is no doubt that the disease was checked by this means. There occurred several instances where the first sufferer in a family of children being promptly removed, no spread of the disease occurred. The risk that the establishment of this temporary hospital entailed upon the workhouse itself, was fortunately followed in this instance by no ill result.

The elementary schools were closed for the summer holidays from August 9th to September 6th, and on September 10th, in consequence of the scarlatina prevalence, for a further period of three weeks.

The epidemic subsided from the time (September 20th) when isolation was enforced, but precautions were relaxed prematurely. On October 1st the schools were re-opened, and on October 25th the isolation wards were closed and the nurse discharged. On the 30th it was found that the disease had reappeared; and now, in this second outbreak, there can be little doubt that the infant school was a centre of infection. It appears that for some days previous to November 1st a monitress there was coming from an infected house, she being occasionally engaged, it is said, in nursing her two fever-stricken sisters; and within a week of the date named, nine children of different families attending the school sickened of the disease. This school, the average daily attendance at which was some 118, was again closed on the 2nd November, and remained closed until January 14th, 1889. On October 30th the wards at the workhouse were re-opened to fever cases, and isolation again enforced.

*The Sanitary Condition and Administration of the District.*

The Poor Law Medical Officers are the Medical Officers of Health for their respective districts. In each case the salary is 10*l.*, no part of which has been repaid from the Parliamentary grant. The districts are as follows:—

| District. | Date of Appointment of present Medical Officer of Health. | Area. | Population. |
|---|---|---|---|
| Faringdon - - | 8th February 1883 - | 12,255 | 4,845 |
| Lechlade - - - | 8th February 1888 - | 10,439 | 2,243 |
| Shrivenham - - | December 1881 - - | 14,714 | 2,481 |
| Buckland - - - | 1st June 1887 - - | 22,768 | 4,725 |

The Medical Officers of Health report at quarterly and yearly intervals. In the reports presented for the last three years (including the annual reports of 1885), I can, except in one instance, find no definite information regarding the sanitary condition of either of the four districts. The exceptional instance is that of a report by Dr. Miller, late Medical Officer of Health for the Lechlade District, who, à propos of an outbreak of typhoid fever in the second quarter of 1886, states that he had made a house-to-house inspection of the greater part of the village of Lechlade, and found that the well-water was in a large majority of cases polluted by surface filth. The effect of the Medical Officer's activity in this single instance is noteworthy. Following it, the Authority entered upon a scheme for supplying Lechlade with water from a general source. The Medical Officer of Health complains in the next annual report that he had not been consulted upon the proposed scheme, and expresses some doubt, apparently with reason, as to the freedom of the projected source of water supply from risk of contamination. Moreover, up to the present date, little progress has been made with the work. Still the fact remains that when adequate representation was made to the Sanitary Authority notice was taken of it, and action was thereupon commenced.

The remaining reports have consisted chiefly of complaisant remarks upon the health of the district and congratulations upon its sanitary state. I cannot find that any advice has ever been offered as to providing the district with means of defence against epidemic disease. The provisions of the Public Health (Water) Act, 1878, as they affect rural districts, have not been mentioned. No recommendations have ever been made to the Authority upon the administration of the Dairies, Cowsheds, and Milkshops' Order, and although there are many large dairy farms in the district needing attention, no inspection has, so far as I can ascertain, ever been made of them on behalf of the Authority.

My own inspection does not corroborate the high opinion as to the sanitary condition of the district, that might be formed from the reports of the Medical Officers of Health. I will summarise the result of my observations:—

*Faringdon* town drains to the "stream ditch," a small stream which intersects the town, and the greater part of which is now culverted. Above, at the outskirts, a considerable number of houses drain to the yet uncovered and muddy bed of the stream so as to cause a nuisance; lower down, the culvert itself is "ventilated" by one six-inch shaft, if indeed a six-inch shaft to a culvert five feet in diameter can be regarded as "ventilation." The tributary sewers have been laid at various times within the last 30 years; they are said to have, with one exception, a good fall, and to be provided with means of flushing. Ventilation is only provided for by some 20 three- or four-inch shafts,

several of which have been put up during the last two years in consequence of complaints of the foulness of the sewers.

The private drainage of the town is very defective. A large number of houses are provided with pan or hopper closets, connected with the sewers, but having no flushing apparatus. These are generally very foul, the water supply available being scanty and flushing accordingly neglected. Ventilation of the inadequately flushed drains, which discharge into wholly insufficiently ventilated sewers, is almost unknown. In many cases drains pass beneath houses, no special precautions being used, and gullies with direct connexion are occasionally within the houses (cellars, &c.). The escape of drain air in and about houses is a common cause of complaint.

A number of privy cesspits, roughly constructed, deep and porous, still exist, and often constitute a serious nuisance. No public provision is made for refuse removal. Heaps of ashes and house refuse are allowed to accumulate on the bare surfaces about dwellings, and, notwithstanding that the soil is generally porous, often in proximity to water supplies.

There are three public pumps, the principal of which, and the one most resorted to, is in the market place. To this one the water is believed to flow in a subterranean stream from higher ground to the west of the town. The water makes its appearance first in the cellar of a house in the market place, and thence is conveyed to the tanks from which the pump is supplied. In the cellar in question the escape of sewer air from a drain was complained of, and a few yards above, just over the supposed course of the subterranean stream, I noticed a large accumulation of house refuse. Dr. Voelcker, to whom a sample of this water was submitted for analysis in 1870, found it to contain an appreciable though small quantity of organic impurity, "unquestionably of animal origin." He concluded that although the water could not, in his opinion, be said from this analysis to be "decidedly unwholesome," its condition should be jealously watched, and if found varying in colour, or giving off the slightest smell at any time, should be permanently discarded.

He spoke of the water as "well water," thinking apparently that it was from a well of the ordinary kind. It is really a shallow flowing current, probably at its source just outside the town free from the evidence of animal contamination found in it—a water, that is to say, concerning which such evidence is in a higher degree suspicious than in the case of deep well water.

Apart from the users of this water, the greater number of the inhabitants of the town appear to depend upon private wells. These are often sunk in close contiguity to various sources of pollution; and in certain cases I heard of water habitually in use being from time to time obviously befouled.

The house accommodation of the town requires much attention. The cottages are often very small, the rooms ill-ventilated, and occasionally overcrowded. Dampness, both from the roof and from the foundations, is little guarded against; certain houses in Foundry Yard, for example, are quite unfit for habitation from this cause.

In the remaining villages of the district no regular means of drainage exist. Highway drains, for the most part channels with stone walls and cover, and the bare earth for the floor, and with communicating drains of stone or land-tile pipes, are frequently used for the purpose of sewage removal (as at Lechlade and Shrivenham); or (as at Uppington) sewage is thrown into some adjacent ditch, or into a hole dug for the purpose in proximity to the dwelling. So much of the sewage as finds its way

out of the villages by the channels above spoken of is discharged for the most part into the Thames, or one of its tributaries. For excrement disposal, large deep privy pits, rarely emptied and very foul, are almost universally used both for the cottages and for the village schools. In the villages along the edge of the chalk downs, water is obtained from springs or from wells in the chalk, often imperfectly protected from surface pollution; and elsewhere from shallow wells sunk not unfrequently in the midst of manured garden ground, and besides other sources of contamination. Occasionally streams and ditches polluted by sewage are resorted to. There are a considerable number of very old and dilapidated dwellings, and several so damp as to be unfit for habitation. Overcrowding in small ill-ventilated rooms was observed in some few cases.

Conditions such as these, urgently calling for the Authority's attention, were observed in each of the divisions over which the several Medical Officers of Health are required to exercise supervision. Apart from instances in Faringdon town, the following places may be mentioned, as examples merely: In the Faringdon District, "Roadside Houses," Eaton Hastings; in the Lechlade District, Lechlade Square, where typhoid fever has recently broken out; Thames Street, Lechlade; in the Buckland District, various localities at Uppington, where typhoid fever has from time to time made its appearance; near Kingston Lisle, where a small outbreak of diphtheria recently occurred, and at Stanford; in the Shrivenham District, Clay pit houses, houses in Haye's Lane, Shrivenham.

There are two Inspectors of Nuisances, each of them acting also as Relieving Officer, District Registrar, and Vaccination Officer. Mr. Wright, of the Faringdon Division, has 20 parishes under his charge, and as Inspector of Nuisances receives a salary of 20*l.* per annum; Mr. James Morse, of the Shrivenham Division, has 10 parishes, and receives a corresponding salary of 10*l.*

Mr. Wright, the Inspector of Nuisances for the larger (Faringdon) division, admits that he has not time for the work, and expresses his wish to be relieved of the office. He and the Medical Officers of Health never inspect the district in company. Mr. Morse's books record twelve instances of his intervention during the last two years in securing the removal of nuisances, nearly all these of a recurring kind—overfull privy pits, &c. Probably both he and Mr. Wright have done much in an informal way in keeping down such nuisances, but of real permanent improvement from structural work there is an almost entire absence.

## No. 12.



On Scarlet Fever associated with Diphtheria and Sore Throat, at Macclesfield and Upton, in connexion with milk supply; by Dr. Parsons.

### Report on an Outbreak of Scarlet Fever, with associated Diphtheria and Sore Throat, occurring in the Macclesfield Rural and Urban Sanitary Districts in connexion with a particular supply of Milk; by Dr. Parsons.

Circumstances under which inquiry was made.

On February 7th, 1889, the Local Government Board received from the Macclesfield Rural Sanitary Authority a communication informing them of a severe outbreak of disease which had occurred within the previous ten days in the township of Upton in their district. The disease was described as "resembling scarlet fever (especially in children)," but "accompanied by diphtheritic sore throat and symptoms "of blood poisoning." It was stated that the milk supply in all cases had been obtained from the same farm, and that a number of cases of similar character had also occurred in the borough of Macclesfield among people who had obtained their milk from the same source. No sickness among the cattle at the farm or in the farmer's family had been found. The letter concluded with a request for the assistance of one of the Board's Inspectors to investigate the outbreak, and was accompanied by a memorial from some of the inhabitants of Upton to the same effect.

Description of locality.

In compliance with this request I was directed to undertake the duty. On my arrival at Macclesfield on February 11th, I met the officers of the Rural Sanitary Authority, and learning from them that, concurrently with the outbreak in Upton, there had been a large number of cases of scarlet fever in Macclesfield, I requested and obtained from the Board instructions to extend my inquiry to the borough so far as was necessary for an understanding of the outbreak.

The township of Upton is a small one, containing, in 1881, 39 inhabited houses with 185 inhabitants. It now contains 41 houses and 228 inhabitants. Most of the houses are on the side next Macclesfield, forming practically a suburb continuous with the borough; they are villas inhabited by private residents and people of the middle class who have business in the town. They are supplied with the town water, but do not drain into the town sewers, the sewage being carried into cesspools or water courses. There are also a few farm houses and cottages. The situation is elevated about 500 feet above the sea level, and the soil is sandy.

The part of Macclesfield immediately adjoining Upton is of similar character, but further in the town are streets of smaller houses inhabited by artizans. It is on the side of Macclesfield towards Upton, the west side, that the scarlet fever has mostly occurred; more distant parts, comprising the older, lower, and poorer parts of the town, having almost escaped.

As the circumstances of the outbreak were the same on both sides of the artificial line which separates Upton from Macclesfield, it will be

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convenient to treat of it as a whole; and the account given of it will be understood to apply to both places unless one or the other is specially mentioned.

The outbreak has been sudden in its onset. In the borough of Macclesfield the notification of cases of infectious disease is compulsory upon medical men under the Macclesfield Corporation Act, 1882. The following is the number of cases of scarlet fever reported to the Sanitary Authority under the provisions of that Act, since the commencement of the year 1889:—

Sudden outbreak of scarlet fever,

| Week ending. | Cases. |
|---|---|
| January 5 | 1 |
| „ 12 | 1 |
| „ 19 | — |
| „ 26 | — |
| February 2 | 32 |
| „ 9 | 7 |
| „ 16 | 4 |
| „ 23 | 2 |

In Upton no cases of scarlet fever are known to have existed before January 24th, but between January 24th and February 1st, 10 cases of scarlet fever occurred, in seven different households. The Macclesfield Rural District, an extensive area, had, so far as known, been previously almost free from scarlet fever. Some cases occurred in the latter part of December in Prestbury, a village beyond Upton, and in the latter part of January and beginning of February, besides the outbreak in Upton, scattered cases were reported in seven different and widely separated townships, viz., Mottram St. Andrew, Bosley, Chelford, Rainow, Prestbury, Macclesfield Forest, and Langley.

The four former places are outlying villages, distant from Upton. The cases at Prestbury, Macclesfield Forest, and Langley, were inquired into by me. There was in most of them a history of probable exposure, at school or at home, to infection from previous cases, known or unrecognised.* The only connexion traceable between any of these and Upton was that two children, living in an outlying cottage in Upton and using no milk, but going to Prestbury school, were taken ill of scarlet fever on January 24th and 30th respectively. These cases, however, were apparently unconnected with the main outbreak at Upton.

accompanied by cases of severe sore throat,

It was noticed that the cases of scarlet fever in Upton and Macclesfield were accompanied, often in the same household, by a more numerous series of cases of sore throat, occurring chiefly in older persons, varying in severity, the more serious having a diphtheritic tendency, and two developing into distinct diphtheria. The cases which were termed scarlet fever appear to have presented certain peculiar clinical features, to which I shall have to refer later on.

among customers of a particular dairyman,

It was further remarked, by January 31st, that all or almost all the patients in Upton and Macclesfield had procured their milk from a Mr. V., a farmer and milk seller of Upton, and on that day two medical men took the responsibility of calling on Mr. V., and, although they

* Since this report was issued it has come to my knowledge, in the course of another inquiry, that scarlet fever was extensively prevalent in December 1888 and January 1889 at places in Derbyshire and Staffordshire adjoining Macclesfield Forest, in the hilly country between there and Buxton.—H. F. P.

could find nothing on his premises to account for the outbreak, of advising him to discontinue the sale of his milk. With this advice Mr. V., much to his credit, complied. No milk was sent out after the morning delivery of January 31st, and after that day the number of fresh cases of scarlet fever and associated sore throat rapidly declined.

I shall have to show by figures that the inferred connexion of the outbreak with the distribution of Mr. V.'s milk was thoroughly justified, but before doing so I wish to disclaim imputing blame to Mr. V. for the misfortune which has happened to his customers and himself, and to add my testimony to the care and intelligence with which his business is managed; to his readiness to afford me all information; and to his desire to do his duty to his neighbours even at the cost of present loss to himself.

I was furnished by Mr. V. junior with lists of the customers of the dairy in the order in which they were visited, and with the daily quantity of milk taken at each household. In all, 103 households took the milk, of which 41 were served in the morning only, 22 in the evening only, and the remainder both morning and evening. The round commenced at Upton and went on to Macclesfield, the order in which the houses were visited in the latter part of the round being somewhat different in the morning and the evening. I may here state that no difference was observed in the incidence of disease upon the consumers of the morning and of the evening milk, except that those who took milk both morning and evening took on the whole a larger quantity, and suffered more than those who took it only once a day.

Of the 103 houses where the milk was taken, information as to the number of inmates and the occurrence of sickness was obtained at 100; at the remaining three the parties had removed. The 100 houses contained 492 inmates, of whom 150 were under the age of 15 and 352 above that age; and there had occurred in them recently 38 cases of scarlet fever, two of well-marked diphtheria, and 83 of sore throat of greater or less severity. In 58 out of the 100 houses, cases of one or other of these forms of diseases had occurred, and 123, or 25 per cent., of the inmates had been attacked. The appended table, Addendum No. I., shows the particulars as regards the several households. The incidence respectively on persons under and above the age of 15 will be mentioned in a later paragraph.

The first 22 households are in Upton township. They are mostly houses of the better class at which a good deal of milk was drunk; 17 of them had been invaded by disease. The 22 houses contained 106 inmates (of whom 23 were under 15 and 83 above that age); of these 40, or 37·5 per cent., were attacked by disease in one or other form. For the sake of comparison all the other houses in Upton township (18, besides Mr. V.'s own) were visited. They contained 116 inhabitants (of whom 41 were under 15, and 75 above). Among these, cases of illness were found at three only, viz.:—

1. Two cases of scarlet fever, the first commencing January 24th, clearly traceable to attendance at the Prestbury village school, at which persons had been attending from infected houses.
2. Three cases of "mumps," the first about December, in the cottage adjoining 1.*
3. A slight case of sore throat about the latter part of January.

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* So far as I can learn these were really cases of mumps, and not true sore throat; but in order to avoid any suspicion of unfairness in the comparison, I have thought it best to include them in the table.

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Counting all these, we get the following comparison:—

Households in Upton.

| Milk obtained from | Households. | Inmates. | Cases of | | | Percentage attacked. | |
|---|---|---|---|---|---|---|---|
| | | | Scarlet Fever. | Diphtheria. | Sore Throat. | Households. | Persons |
| Mr. V. - - - | 22 | 106 | 8 | 1 | 34 | 77·0 | 37·5 |
| Other sources, or none - | 18 | 116 | 2 | — | 4 | 16·7 | 5·2 |

In Macclesfield a similar numerical comparison can only be made in respect of the cases returned as scarlet fever. In the week ending February 2nd 1889 there were notified 32 such cases, of which 28 were persons habitually using Mr. V.'s milk. Mr. V. supplies 78 households in Macclesfield, containing 386 persons. There are 60 registered milk dealers selling milk in the borough, so that as the borough contained in 1881 8,552 inhabited houses, and 37,514 inhabitants, each dealer would supply on an average 142 houses and 625 persons, or nearly twice as many as Mr. V. Probably, however, the proportion which Mr. V. furnishes of the total amount of milk used in Macclesfield is greater than the proportion of houses supplied by him, since many of his customers are of the well-to-do class, who use a good deal of milk.

Of the four cases of scarlet fever notified in the week ending February 2nd in persons not habitually drinking Mr. V.'s milk, one occurred in a house in which there had been a previous case some weeks before; it was in a low part of the town, and the back yard and privy were used jointly with a common lodging house. Another child had probably occasionally drunk Mr. V.'s milk. The other two cases occurred in one house, with an interval of three days between them; the source was not discovered.

Of the seven cases notified as scarlet fever in the week ending February 9th, three were in persons who had been using Mr. V.'s milk. The others occurred in different parts of the town (two in one family), and some of them in association with cases of measles.

Two or three cases of sore throat among persons not using Mr. V.'s milk were heard of in the course of the inquiry, but I am informed that sore throats have not been especially frequent in Macclesfield lately, except mumps, which has been rather prevalent.

especially incident upon large consumers of milk

The case against the suspected milk is further strengthened when we come to consider the question of the quantity consumed by different persons. By the aid of the figures which I have obtained and given in the table in Addendum No. I., I am able to arrange the households in which Mr. V.'s milk was used in four classes, according to the average amount of milk per head used daily therein, with the result that the incidence of the disease both upon households and persons is shown distinctly to vary according to the quantity of milk used.

| Average daily amount of Milk used per head. | Households. | | Inmates. | | Cases. | | | Percentage attacked. | |
|---|---|---|---|---|---|---|---|---|---|
| | Total. | Attacked with Scarlet Fever or Sore Throat. | Under 15 years. | 15 and above. | Scarlet Fever. | Diphtheria. | Sore Throat. | Households. | Persons. |
| 1 pint and upwards - - | 9 | 8 | 10 | 30 | 8 | — | 12 | 89 | 50 |
| ⅔ pint and under 1 pint - - | 16 | 12 | 35 | 62 | 11 | 1 | 21 | 75 | 34 |
| ⅓ pint and under ⅔ pint - - | 37 | 21 | 37 | 123 | 10 | 1 | 34 | 56 | 28 |
| Under ⅓ pint - - - | 38 | 17 | 68 | 127 | 9 | — | 16 | 45 | 12 |
| Total - - - | 100 | 58 | 150 | 342 | 38 | 2 | 83 | 58 | 25 |

The use in a household of a large proportion of milk usually indicates that milk is partaken of on several occasions during the day, and that it is used as a beverage, and not merely as an adjunct to tea or coffee, or in puddings. In the event of the milk becoming infected it implies that a larger total amount of poison is imbibed, that the occasions of exposure to its influence are more numerous, and that a larger proportion of what is taken has not undergone any process, as of cooking, which would destroy or impair its activity.

Many instances were met with in which those members of the household who were attacked, or were attacked first, were the chief drinkers of raw milk; and, on the other hand, in which the members who escaped were those who drank little or no milk, or drank it only boiled. Some of these instances are noted in the last column of the appended table. The proportion between the amount of milk taken, and the amount of sickness, though well marked when a series of cases is taken, was, however, in individual cases often interfered with by other circumstances, *e.g.*, the age of the inmates, the number of them protected by previous attacks, the sending away of other members of the household on the occurrence of the first case, the boiling of the milk wholly or in part, and its use in different modes and in unequal proportions by different members of the household.

The outbreak did not show any special incidence on children, if all the cases of whatever type be reckoned together; the percentages of persons attacked under and above 15 years being practically the same, 24·7 and 25·1. [Taking, however, only the cases classed as scarlet fever, the percentage of persons using the suspected milk who were attacked was 16·7 of those under 15 years and only 3·8 of those above, or less than a fourth.] In many epidemics of throat illness ascribed to a milk origin, a greater incidence on children has been noticed, and has been connected with children being generally the largest milk drinkers. In the present case, however, there has been no special use of milk by children. From the table above it will be seen that in the households in which a pint or more of milk per head was used, of 40 inmates, only 10, or 25 per cent., were under 15, while in those in which less than one-third of a pint per head was used, out of 195 inmates 68, or 35 per cent., were under 15. I found that many adults were in the habit of drinking milk for supper, and of taking it cold with porridge for breakfast. In fact the proportion of milk used in a household depended more upon individual habit and on the possession of the means to buy it than upon the number of children in the household.

The severity of the illness has appeared (age for age) to depend upon the amount of milk which the patient was in the habit of consuming. The

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great majority of the severe cases, and two out of the three fatal ones, have occurred in households in which a large quantity of milk per head was taken, and in persons who were great milk drinkers. On the other hand many of the cases which have occurred in households (chiefly those of the artizan class) in which a small relative amount of milk was taken have been of a mild or doubtful nature; they were not attended by a medical man, and were only heard of by making a house-to-house inquiry at all the houses where Mr. V's milk was taken.

Clinical features.

As already mentioned, the cases of illness, associated together in the present outbreak by the connexion of a common milk supply and a nearly simultaneous commencement, have presented differences in symptoms, which have led to some being classed as scarlet fever, others as diphtheria, and others again as diphtheritic sore throat or simply as sore throat. Some of the milder cases of sore throat, such as those lately referred to, may have been of a different nature, or due to ordinary causes, but so far as the information which I have been able to obtain of the clinical history of the cases has enabled me to judge, I am of opinion that all the severe and well marked cases, by whatever name called, have been essentially of the same nature and due to the same cause, the differences between them depending upon the age and constitution of the patient, and the amount of the poison taken. The seed has been the same in all cases; the crop has varied according to the amount of it sown, and the nature of the soil on which it fell. My reasons for this opinion are:—

1st. That the cases of scarlatinal type have occurred chiefly in children under 15 (25 out of 38), and the remainder mostly in young adults, or in persons who had not had scarlet fever before; while the cases of sore throat without rash have occurred chiefly in older persons, in whom rashes on the skin are less prone to develop and less readily seen; or in those in whom the complete development of scarlet fever was prevented by the patient having previously suffered from an attack of that disease.

2nd. That in a few cases of persons who had suffered from sore throat, but on whom no rash had been seen, the skin was afterwards found to be peeling.

3rd. That in many of the households in which children suffered from scarlet fever, older persons suffered at the same time from sore throat without rash.

4th. Both of the well marked cases of diphtheria were similarly accompanied by cases of sore throat of a less severe and not distinctly diphtheritic character.

5th. The severer cases of sore throat,—"diphtheritic sore throat"—are described as having presented scattered dots of whitish deposit on the tonsils around the mouths of the follicles: in the distinct cases of diphtheria, similar dots coalesced into a continuous false membrane.

6th. In some of the cases of scarlet fever similar dots of deposit, in one case coalescing into a continuous membrane, were observed. The concurrence of the symptoms of diphtheria with those of scarlet fever in the same patient, or in casually connected cases, has not unfrequently been observed in other outbreaks.

7th. In the severer cases of sore throat without rash the sudden coming on of the sore throat and feverishness, and the frequently present delirium are symptoms resembling scarlet fever.

Some cases resembled scarlet fever.

The cases of scarlatinal type have presented the following clinical features. The disease has commenced suddenly, very commonly with

vomiting, even in adults, and in some cases with purging also; with sore throat, headache, pains in the limbs, and prostration. A feeling of chilliness sometimes occurred, but in a few cases only were there distinct rigors. There was rapid onset of fever, the temperature in one case reaching 105° F. on the first day. Sore throat was present from the first, the fauces were inflamed (described as having been of a dark red colour like port wine), the tonsils were enlarged, and there was also an enlargement, in bad cases considerable, of the cervical glands below the jaw. In some cases a distinct fibrinous exudation appeared on the tonsils, thus connecting the cases of scarlatinal with those of diphtheritic type. The tongue rarely presented the white fur and red enlarged papillæ ("strawberry tongue") characteristic of scarlet fever; it was more often covered with a thick moist creamy white or dirty brown coat, or in other cases was red and smooth. The rash, which was the distinctive feature of the type, began about the second day; in one case within 24 hours of the first symptoms, in another not till the fifth day; it was a copious scarlet rash, described by some of the medical men as resembling the ordinary rash of scarlet fever; but two medical men under whose care many severe cases had come, Messrs. Somerville and Hughes, considered that it differed somewhat from the scarlatinal rash as commonly seen; they described it as presenting, besides a scarlet blush, purplish blotches (compared to the mottling on the skin of a healthy infant after a bath); it appeared sometimes first on the hands and feet; and it was followed only by a very slight desquamation. The last statement I can verify from my own observation: through the courtesy of the medical men in attendance I had the opportunity of seeing, towards the end of the third week of their illness, more than a dozen cases of scarlatinal type, in which there had been a copious rash; in only one of these was there distinct peeling of the skin; and that only on the hands; in the other cases the desquamation was so slight as to be barely perceptible; nor had there been more at an earlier stage.

In several cases the disease was accompanied by rheumatism of the joints, especially the wrists. In several cases (especially in one family) there were symptoms of ear mischief, viz., prolonged ear-ache, partial deafness, and in one or two instances offensive purulent discharge from the ear. In one case there was profuse watery discharge from the nose. In no case were kidney symptoms observed, nor was albuminuria found on any occasion on which it was looked for. Delirium was generally present in severe cases. The fever lasted about six days, or in some cases longer; in several there was a distinct relapse with a recurrence of throat symptoms about the tenth day. It left very considerable prostration. Only two cases out of 38 were fatal; the cause of death being certified as "malignant scarlet fever."

The scarlatina appeared to have little tendency to spread in the households into which it had been introduced. In 19 households there were multiple cases (cases of sore-throat occurring in households in which there had been fever being included), but in only five of these did an interval of four days elapse between the commencement of the first and second cases, and in only three did cases occur later than February 7th, *i.e.*, more than a week after the stoppage of the suspected milk.

This failure to propagate itself by infection from case to case, may have been due in some households to the fact of all the children having been attacked at the beginning, so that there were no susceptible individuals left to contract the disease from them. In others it may have been due to the precautions taken to separate the sick from the healthy, the more so as the greater number of the households invaded

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were of the well-to-do class, in which such precautions are more feasible than among the poor. So far as it was not thus explicable, the absence of tendency to spread may be connected (if the popular theory be correct that the scales shed from the skin are the chief carriers of infection) with the very slight amount of desquamation generally exhibited. A similar indisposition to spread by contagion has, however, been observed in other scarlatina epidemics of milk origin in which there has been no lack of peeling of the skin.

It will be seen from the foregoing sketch that the features of the disease have on the whole been those of scarlet fever, but that the outbreak has presented certain peculiarities, viz. :—

The frequency of vomiting and purging at the commencement.
The state of the tongue.
The character of the rash.
The scanty desquamation.
The slight tendency to spread by infection.
The absence of, at any rate conspicuous, kidney symptoms.

It is right to state that Messrs. Somerville and Hughes, to whom I am indebted for much of my information as to the clinical history of the disease, doubt that it has been scarlet fever, and are inclined to look upon it as a form of blood poisoning due to sewage matter conveyed through the medium of milk.

other cases resembled diphtheria,

In the course of the outbreak there have occurred two well-marked cases of diphtheria; besides a number of cases classed as "diphtheritic sore throat," and one or two in which a diphtheritic exudation appeared on the tonsils in the course of scarlet fever. The cases classed as diphtheria have been marked by the presence on the tonsils of a distinct false membrane, continuous, whitish, and fibrinous, and by the absence of a red rash on the skin.

In one case, in an elderly but previously healthy man, the diagnosis was confirmed by Dr. Renaud, physician to the Monsall Fever Hospital, Manchester. Albuminuria was present in this case, which proved fatal suddenly on the 12th day. The other case was in a young man, who was said to have previously suffered from an attack of "diphtheria" in infancy, at a time when the other children in the house were ill of scarlet fever. He was not known to have had scarlet fever then or since, but was liable to sore throat. His illness began with sore throat and shivering; on the second day he had a high temperature, but no rash; both tonsils and soft palate were covered with a yellowish white membrane, which was coughed up on the fifth or sixth day "like a piece of leather." There was not much enlargement of the glands in the neck; and no albuminuria was found on the only occasion on which it was looked for. No peeling of the skin, or local paralytic symptoms followed.

others merely sore throat.

The cases classed as "sore throat" comprised those in which neither scarlet rash nor distinct diphtheritic membrane was present. They occurred mostly in adults and many of them in households in which other members had scarlet fever or diphtheria. They varied in severity from a feeling as of a common "cold," with slight soreness of the throat passing away in a few hours, to a serious illness, accompanied by fever and delirium, and confining the patient to bed for two or three weeks. No case, however, was fatal.

The local appearances were redness of the fauces, enlargement of the tonsils, with, in some cases, superficial ulcerations, or scattered dots of exudation at the mouths of the follicles, not, however, coalescing into a continuous membrane. Up to the time to which my information

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reaches, no case had been followed by symptoms of local paralysis, such as frequently (though not in all outbreaks) occur after diphtheria.*

The dates of the commencement of illness in the households supplied with Mr. V.'s milk, were as follows :—

Dates of outbreak.

| Date. | Households newly invaded. | Cases in Households newly invaded. | | | Cases in Households previously invaded. | | Total New Cases. | | | Grand Total of Cases. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Scarlet Fever. | Diphtheria. | Sore Throat. | Scarlet Fever. | Sore Throat. | Scarlet Fever. | Diphtheria. | Sore Throat. | |
| January 24? * | 2 | 1 | — | 1 | — | — | 1 | — | 1 | 2 |
| „ 25 | 3 | 3 | — | — | — | — | 3 | — | — | 3 |
| „ 26 | 4 | — | — | 4 | 1 | — | 1 | — | 4 | 5 |
| „ 27 (Sunday) | 9 | 6 | — | 3 | 2 | 3 | 8 | — | 6 | 14 |
| „ 28 | 9 | 2 | — | 9 | 3 | 2 | 5 | — | 11 | 16 |
| „ 29 | 2 | 2 | — | 2 | 4 | 2 | 6 | — | 4 | 10 |
| „ 30 | 8 | 2 | 1 | 6 | 6 | 5 | 8 | 1 | 11 | 20 |
| „ 31 } Milk discontinued after | 6 | 2 | 1 | 11 | 1 | 2 | 3 | 1 | 13 | 17 |
| February 1 } morning of 31st | 1 | — | — | 1 | 1 | 2 | 1 | — | 3 | 4 |
| „ 2 | 2 | 1 | — | 2 | — | — | 1 | — | 2 | 3 |
| „ 3 | — | — | — | — | — | 2 | — | — | 2 | 2 |
| „ 4† | 3 | — | — | 3 | — | — | — | — | 3 | 3 |
| Dates not accurately known, but within above period. | 9 | — | — | 9 | — | 12 | — | — | 21 | 21 |
| Later | — | — | — | — | — | 2 | 1 | — | 2 | 3 |
| Total‡ | 58 | 19 | 2 | 51 | 19 | 32 | 38 | 2 | 83 | 123 |

* Of the two cases recorded as commencing on January 24th, one began late at night (or perhaps early on the morning of the 25th). The date of commencement of the other was somewhat doubtful; it was not notified to the borough authorities as scarlet fever until February 4th.

† Of the three cases of sore throat recorded as commencing on February 4th, two were of doubtful nature; of the other the date was somewhat uncertain.

‡ In several instances two or more cases of sickness among the members of a household commenced on or about the same day.

It will be seen that the outbreak may be said to have commenced on January 25th and ceased on February 2nd; the great bulk of the cases having occurred between January 27th and 31st. These dates are of importance in seeking for the cause of the outbreak. The speedy falling off of the number of new cases after the stoppage of the milk, shows that the incubation period of the disease could not have been a long one; and the cause must therefore have been some circumstance or combination of circumstances which came into operation only a day or two before January 25th. The fact that fresh cases continued to occur during a period of at least nine days points to the milk having received a continuous supply of infection, rather than to its having become casually infected on one or two occasions only.

Having shown that the outbreak of scarlet fever and associated sore throat was due to infection distributed in Mr. V.'s milk, and that the milk must have become infected first within a few days before January 25th, we have now to inquire how the milk could have become infected. We have therefore to consider the circumstances of Mr. V.'s establishment with reference to—

Circumstances of dairy.

1. The sanitary condition of the premises.
2. The health of the inmates.
3. The routine of the business.
4. The health of the cows.

* One case was subsequently followed by a partial loss of sensation in the legs. Two cases in which no rash had been observed were followed by peeling of the skin.

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Mr. V.'s establishment was first visited in relation to the outbreak, on January 31st by the medical officers of health for the Macclesfield Urban and Rural districts, and by two other medical men. I myself visited it on February 11th and on several subsequent occasions, and as I have already said, found Mr. V. always most willing to give any information which might throw light upon the subject of the inquiry.

Sanitary condition.

Mr. V.'s establishment is a farmhouse in Upton, standing by itself a little way back from the road. The surrounding surface and the interior of the house were, at the time of my visit, scrupulously clean. The scullery sink-pipe discharges in the open air. In the cellar in which the milk stands (when any is kept over) there is a "sump" in the floor to catch water when the floor is washed; this was formerly connected with the drain, but the connexion is said to have been severed, and no offensive smell or current of air from the sump was discovered by me. The cellar wall was damp in the corner nearest to the privy. The privy is built against the house wall, and is entered from the wash house; it is insufficiently ventilated, and at my visit was very offensive. The space under the seat is connected with a drain which receives also the liquid from adjoining pig-styes, and discharges into a tank about 35 yards distant, the contents of which are pumped out once a year (last in March 1888) and distributed over the land. The water supply of the household has, until after the outbreak, been obtained from a pump in the yard. The well is about 7 yards from the privy and pig-styes; the water had always been considered good, but at one of my visits it was turbid, with an unpleasant taste: becoming more turbid with floating particles on prolonged pumping. On analysis it was pronounced to be contaminated with sewage and unfit for drinking purposes. (See Addendum, No. II.) This water was used for rinsing the milk cans, but (with certain exceptions to be hereafter mentioned) it was not drunk by the cattle, who resorted to a spring in a field, not likely to receive sewage pollution.

Health of inmates.

Mr. V.'s household consists of himself and Mrs. V., their adult son, two lads, and a servant girl. All the work of the establishment is done by them without any outside help. On inquiry as to their health, I was informed that Mrs. V. had had a bad cold on January 26th and lay in bed on Sunday morning, January 27th, but was better next day; her throat was said by one of the medical men who saw her on January 31st, to have been then red, and there was some redness and enlargement of one tonsil at my visit on February 11th, but no peeling of the skin could be detected. She is said to be liable to sore throat, and even if her ailment had been of the same nature as the other cases, the date shows that it could only be looked upon as an incident in the outbreak and not as its cause. The other members of the household (who drank a good deal of milk) had all been perfectly well, and were free from sore throat or peeling of the skin. One of the lads had come from Pendleton near Manchester on December 31st, none of the others had been away from home further than Macclesfield.

Nearest cases of scarlet fever.

In December and January scarlet fever was prevalent in the neighbouring village of Prestbury, two miles from Upton. It was evidently spread by personal communication between the children of different households at school and elsewhere. At the time of my visit the village school was closed on account of a case of scarlet fever in the schoolmaster's family. Two children in a family living at Back Lane, Upton, in a cottage about a quarter of a mile from Mr. V.'s farm, were taken ill of scarlet fever on January 24th and 30th respectively; both had attended Prestbury school up to the time of their illness, and the child first taken ill had sat next to one who had recently returned to school

after an attack of scarlet fever. They had used no milk before the illness. No communication could be ascertained to have taken place between Mr. V.'s household, and this family, or any of those at Prestbury.

Routine of business.

Mr. V.'s business consists ordinarily solely in the purveying of milk. He sells daily 10 or 11 dozen quarts. His milk is obtained on six days in the week solely from his own cows (except that occasionally his son, who takes out the milk, purchases a little on his rounds from other milkmen to make up the required quantity, if his stock should run short). On Sunday morning a larger quantity of milk is required than on other mornings, and the additional quantity, 16 to 21 quarts, is obtained from another farmer in Upton, Mr. L. Mr. L. does not retail his milk, but uses it on week-days to make butter, which he sells to shopkeepers in Macclesfield. On Sunday evenings there is less demand for milk, and what is over of Mr. V.'s supply is allowed to stand for cream. Only three of Mr. V.'s customers had had cream from him during the week before the outbreak.

The cows are milked between five and six a.m., and four and five p.m., by Mr. V., his son, and the servant girl, and the milk after straining is sent out at once; the whole quantity being mixed in one can. The cans are scalded morning and evening with boiling water, they are then rinsed out with cold water, and placed upside down on a stand in the yard to drain dry. The water used for scalding and rinsing the cans is obtained from the pump before mentioned. It is obvious that the contamination of this water—a matter that has doubtless been going on for years—will not by itself suffice to explain the recent sudden outbreak of disease among the milk drinkers.

The milk is taken out by Mr. V., junior, in a large can in a cart; the servant girl or a lad going with him in the first part of the round to help him distribute it. The milk is ladled out into the customers' vessels either direct from the large can, or, at houses standing back from the road, from a smaller can which is filled by ladling from the large one and taken to the customers' doors, and sometimes into the houses, and from this the required quantity s ladled out into the customers' vessels.

It was suggested by Dr. Rushton, medical officer of health for the rural district, and by Mr. V., junior, that the milk might have become infected in the course of delivery in the following way. It seems that it is the custom in delivering the milk to dip it out of the can with a measure and pour it into the customer's jug or basin, which is held over the open can. Any drops of milk which might be spilt would run down the outside of the customer's vessel, and drop off the bottom into the can. If the vessel used to receive the milk had come out of a sick room, or were not clean on the outside—and Mr. V., junior, assures me that he has known such things to take place—the milk in the can might become contaminated. Similarly in filling the small can from the large one, it is thought that the contents of the latter might be contaminated. It does not appear to me that this risk is a great one, but, such as it is, it can easily be avoided by obvious precautions in measuring out the milk. The following considerations moreover appear to be fatal to the hypothesis which attributes the outbreak to infection conveyed in the manner suggested.

*First.* The absence so far as is known—and the opportunities for obtaining information have, in this instance, been unusually complete—of any earlier cases of scarlet fever among Mr. V.'s customers from whom the infection might be derived. All the

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cases have occurred within a period of 10 days or so. Nor have the customers who came earliest on the round been the earliest attacked. The earliest cases were in households Nos. 8, 13, 31, 75, and 78 on the list in Addendum No. I., the latest households attacked were Nos. 5, 42, 24, 55, and 70.

*Second.* Were the hypothesis true, the customers who come last on the milkman's rounds would be the most likely to suffer, since they would run the risk of receiving infection from all visited before them, whereas it will be seen from the table at the end that the houses in Upton which came first on the list suffered more than those which came in the later part of the round; the difference being explicable by the difference in the amounts of milk taken. At the first house on the list the milk was not delivered on the milkman's round, but separately direct from the farm; yet in this house a case of scarlet fever occurred, commencing January 27th.

One household, No. 34, had milk from one cow, besides milk from the general stock. The child who had the milk suffered from scarlet fever, but later than another patient in the house.

The three households, Nos. 2, 3, and 48, at which cream was taken, all suffered more or less severely.

Mr. L.'s milk does not appear to have been concerned in the outbreak; it was distributed only in the morning delivery on Sundays, *i.e.*, on January 20th and 27th, so that had it contained the infection one would have expected a number of cases to have commenced close together about the middle of the week, *i.e.*, after the lapse of a period of incubation of two, or three, or four days after it was distributed. A reference to the preceding table on page 97, will show that this was not so, but that 8 cases commenced on the Friday and Saturday, 14 on the Sunday (several of them beginning in the early hours of the morning), and 16 on the Monday. These would give intervals from the occasions of distribution of Mr. L.'s milk, either too long or too short for the incubation of scarlet fever.*

It occurred to me whether the milk might have become infected by the cloths used for straining it. For this purpose Mr. V. uses bath towels, the soft fluffy texture of which he finds to retain impurities better than the kind of cloth commonly used for the purpose. I am informed, however, that these cloths have been in constant use for straining milk for over two years; that they have never been used for any other purpose, and that they were new when they were bought. Immediately after use they are put into hot water and washed. Every two days the cloths, four in number, are boiled for four hours, rinsed, dried, mangled, and placed in a separate drawer ready for use.

Health of cows.

We have lastly to consider the health of the cows yielding the milk.†

Mr. V.'s herd consists of 14 milch cows, kept in two sheds communicating with each other, at the back of the yard behind his house. The ventilation of the sheds is regulated so as to keep up a temperature of not less than 55° F., there being no artificial means of warming. The sheds are kept clean, the dung and soiled litter being removed three times a day. The cows are fed on chopped hay, turnips, Indian

---

* Mr. L.'s establishment was visited. His household, consisting only of himself, wife, and daughter, were in good health, and exhibited no signs of having suffered from scarlet fever. No history of communication with scarlet fever cases could be elicited. His cattle, only two of which were in milk at the time, were in good health.

† Inquiries were made as to the occurrence of disease among pigs or other domestic animals on the premises, but none was heard of.

corn, and grains. The grains come by rail from Burton-on-Trent; the other articles, except the Indian corn, are grown on the farm.

The cows were examined on January 31st by several medical men, who detected nothing wrong with them. They have since been examined by Mr. Beard, veterinary surgeon, of Macclesfield, and by Mr. Lewis, chief veterinary inspector for Cheshire, who pronounced them in good health (*see* Mr. Lewis's report, Addendum No. III.). They were also examined on February 11th in my presence by Major Landon, veterinary inspector to the Privy Council, whose opinion, I understood, was to the same effect.

On inquiring as to any circumstances in connexion with the herd, which might coincide in time (allowance being made for the period of incubation) with the commencement of the outbreak of scarlet fever, I was informed by Mr. V. that on January 14th he had purchased two new cows of a dealer of repute in Macclesfield, to whom at the same time he sold two cows, which were beginning to run dry, and were getting fat. The latter cows went to a butcher at Manchester.

The two cows bought by Mr. V. were purchased by the dealer from farmers in the neighbourhood, one at Butley and one at Macclesfield Forest, and were brought to the dealer's sheds the day before they were delivered to Mr. V., being stalled there with a number of other cattle collected from the country round. I visited the farm and examined the cows at Butley, and I saw the farmer from Macclesfield Forest, but did not learn of any illness among the cattle at either place, nor of any scarlet fever among the people at either farm. From the farm at Butley the milk is sent to Manchester, at the other it is made into butter which is sold in Macclesfield. The farmer at Macclesfield Forest gives the date of purchase of his cow as January 15th, and if this be correct it would not come into Mr. V.'s possession till January 16th. The dealer had kept no record of the date. The discrepancy is not material to the issue.

Of the two cows bought by Mr. V. on or about January 14th, one had calved about four days before. Its calf was not with it. Its milk was at once added to the general stock. The other cow calved on January 20th. I am informed by Mr. V., junior, that the calving and cleansing were perfectly natural. The milk of a newly calved cow, called by dairymen "beastings," is not at once mixed with the general stock, as it is albuminous and sometimes tinged with blood; it coagulates with heat, and is sometimes used for making puddings and custards. After six milkings it is added to the other milk; but before doing so, Mr. V. takes the precaution to boil some to make sure that it is no longer coagulable by heat. In the case of the cow which calved on January 20th, the "beastings" were not bloody, and presented no peculiar appearance. Only one customer (No. 1 on the list) had any, the calf being allowed to suck.

The milk of the newly calved cow was first distributed with the general supply on the evening of January 23rd, a date which accords sufficiently well with the first outbreak of fever. There is therefore strong ground for suspicion that there was something in the state of this cow that gave the milk its infective quality. On examining the cow on February 11th, I found no scabs or sores on the udder or teats. The cow had a few bare patches, $1\frac{1}{2}$ to 2 inches in diameter, on the rump on either side, around which the skin was scurfy, and the hair could be pulled out. No vesicular eruption on the skin was found. The temperature (February 11th) was 101° F., the normal temperature of the cow being stated to range between 100° and 102° F. On one occasion a yellowish slimy vaginal discharge was noticed.* The calf was healthy

* See postscript, for condition of this cow on March 25th.

and thriving; it had not after the first three days been fed specially on its mother's milk. The other cow bought on or about January 14th had many bare patches on the neck, and a few on the back and rump, on one of which was a thin scab (attributed to scratching). Its temperature on February 11th was 101·4° F. Several of the other cows, especially of those in the same shed with the above, had similar bare patches on the neck, rump, and root of tail; none had any sores or scabs on the udder or teats.

Mr. V. states that he has never had his cattle in better health than they have been all through the present winter, and that they have been remarkably free from chapped teats.

The cows have been kept in the sheds since December, but are let out every day to drink water at a spring in a neighbouring field. The two cows, however, which were bought on January 14th were not let out to drink, but were given water from the contaminated pump-well before mentioned.

(Since January 31st, water from the Macclesfield Corporation Waterworks has been laid on to a tap at Mr. V.'s farm.)

Mr. V. stated that he had not noticed any ropiness or unusual appearance about the milk lately. Nor did I hear from any of his customers any complaint of suspicious appearance, taste, or smell; in fact, the milk seems to have borne an excellent reputation. A sample taken on January 31st was pronounced by the public analyst to be genuine and of good quality: but it must be remembered that the germs of infectious diseases cannot be detected by chemical analysis.

To sum up, while the connexion of the outbreak with the supply of milk from Mr. V.'s farm seems to be beyond doubt, the way in which the milk became infected remains obscure.

The dates of attack of the several cases show that the source of infection, whatever it may have been, came into operation about January 23rd, and continued in operation until the stoppage of the milk on January 31st. No continuous source of infection of human origin can be discovered by careful investigation; the possibility cannot perhaps be absolutely denied that the milk may, on some occasion, have casually received infection from a human source, but there is no evidence that it has done so; moreover, a single such occurrence would not explain the succession of cases, nor, unless it took place at the farm itself, would it account for the distribution of cases among the customers.

The only circumstance that I have been able to discover fulfilling, in point of time, the requirements of the case, is the addition, on January 23rd, to the general stock of milk of that yielded by the cow which calved on January 20th, and the only explanation which suggests itself as to how the milk of this particular cow could have come to have infectious properties is that the cow herself may have developed in the puerperal condition, some ailment so trivial or so evanescent as to have escaped the notice, not only of her owner, but also of the eminent veterinary authorities who at a later stage (first on February 5th) examined her. Such ailment may have originated either from infection brought with her by the cow, or from the sewage-polluted well water which she drank. (The other cow which drank the same water had already calved some four days when she came, and by that time the puerperal condition, with its especial susceptibility to disease, would be passing off.)

It may be remarked that in several instances in which outbreaks of scarlet fever or diphtheria have followed the distribution of milk from a particular dairy, without any extraneous source of infection being discoverable, the dairy in question has been what has been looked upon

as a model one ; in which careful precautions had been taken to exclude risk of infection from human sources, and the cows were well fed and well attended to. In such dairies the cows are kept tied up in sheds at an equable temperature, so that as little as possible of the nutritive material taken in the food may be expended in muscular exercise and in keeping up the bodily heat, and as much as possible recovered in the form of milk. A cow living under these conditions may be looked upon as a milk-producing machine worked at high pressure, and hence perhaps specially susceptible to infection.

Sanitary condition.

As regards conditions other than milk supply, many of the patients were members of the families, or domestic servants, of well-to-do people, living in good roomy houses, with usually fairly well planned drainage and other sanitary arrangements. Others were of the lower middle, and working class, but at few of the houses of Mr. V.'s customers were there any obvious sanitary defects. The water supply was in all cases from the Corporation waterworks, the same as the rest of the borough. Although the persons attacked lived on the west side of the borough, they did not all live in close proximity to each other, but were interspersed among a great many others who were supplied with milk from different sources, and did not have scarlet fever. It was not therefore merely a case of scarlet fever attacking a particular locality in which the majority of houses chanced to be supplied with milk by a particular dealer.

Personal communication.

As regards personal intercourse, the patients were of different ages, sexes, and social conditions; and no occasion was discovered, or was likely to have occurred, at which they could have contracted infection, without other people, who obtained milk from different sources, being involved in an equal risk.

As regards school attendance, the following table shows in how many households the person first attacked attended school, and which schools such persons attended.

Households in which the first patient was—

| | |
|---|---|
| Child under school-going age - - - - | 1 |
| Person above school-going age - - - - | 40 |
| Child of school-going age but not attending school - | 4 |
| Governess at a private school - - - - | 1 |
| Attending Grammar School (one a master) - - | 3 |
| „ High School - - - - - | 3 |
| „ Modern School - - - - | 1 |
| „ Christ Church School - - - - | 1 |
| „ National School, Duke Street - - - | 1 |
| „ Roman Catholic School - - - | 1 |
| Child; at which school, if any, not recorded (one a little girl, one a boy of working class) - - - | 2 |
| | 58 |

There was in certain quarters a disposition to attribute the outbreak to infection spread from the Grammar School, at which there had been an outbreak of scarlet fever in the autumn of 1888. The master's house and the school had been carefully disinfected since the attack. The boarders came back after the Christmas holidays on January 20th, and on January 21st the whole school, including masters and day boys, re-assembled. Three of the head master's children and a boarder were taken with scarlet fever, January 27th–31st, 1889, and another master, not living in the same house, on February 2nd. All these persons were

large drinkers of the suspected milk. Careful precautions were taken to prevent danger to the other boys, and, as a matter of fact, at only one other household was the first patient a boy attending the Grammar School, and he, having met with an accident, had not been at school for some days before the symptoms of fever appeared. Three other day boys attending the same school suffered, but only after there had been other cases in their households, which were supplied with milk from Mr. V.'s dairy. I see therefore no reason to think that the Grammar School had any share in producing the outbreak. On the occurrence of scarlet fever in his family, the head master of the Grammar School removed the patients to an empty house in another street. For this he was much blamed, but the act of removal was not in itself illegal if conducted, as appears to have been the case, with due precautions against spreading the disease; there has been no spread of the disease in the neighbourhood to which the patients were removed, and it is difficult to see what better course could have been taken, in the absence of accommodation for isolating the patients at a hospital which was not then available.

Hospital provision.

The Macclesfield Corporation have a Ducker temporary hospital erected in an open situation outside the town (though within the borough limits). It was erected two years ago on the occasion of an outbreak of small-pox, and has hitherto been reserved for cases of that disease. It contains two wards in one block, each containing six beds with about 1,050 cubic feet of air space apiece. It was not in a state to receive patients at the time when the outbreak of scarlet fever occurred, even if the authority had been willing to allow it to be used for that disease. It has, however, been since made ready for scarlet fever cases from the borough, and at the time of my visit on February 20th one such patient was in it.

At the time of my visit to the district I found that all action immediately necessary had been or was being taken to prevent the spread of the disease. The supply of the suspected milk had been discontinued, Mr. V. using it to make cheese, and agreeing to wait until the meeting of the Rural Sanitary Authority on March 5th before resuming its distribution. The tap water had been laid on to his dairy. At the time of the outbreak the Rural Sanitary Authority were without an inspector of nuisances, the late officer having recently died and a new one not having been appointed. The reconstruction of the privy was left for the new inspector to deal with. At the village of Prestbury a good many matters requiring the intervention of this officer were observed.

I have to thank Dr. Rushton and Mr. Bower, medical officers of health respectively for the Macclesfield rural and urban districts, and other officials, and several of the other medical men practising in Macclesfield, for valuable assistance willingly rendered during the investigation.

### Postscript.

Learning that the resumption of distribution of Mr. V.'s milk had been followed by some cases of scarlet fever and sore throat similar to those in the first outbreak, I visited Macclesfield again on March 23rd.

Although Mr. V. had ceased to take round milk, a few people had fetched it from his farm since my first visit. Among these there had been another case of scarlet fever at household No. 1 in the list, at which there had been a previous case.

On March 6th, with the sanction of the Rural Sanitary Authority, Mr. V. resumed delivering milk, about 60 households taking it. At a

good many of these the precaution of boiling it is said to have been observed. About March 11th one case of scarlet fever, and three of diphtheritic sore throat similar to those in the first attack, occurred, but all of them in households previously invaded, or under such circumstances that their connexion with the milk supply could not be positively affirmed. The following are the particulars of these cases:—

1. Miss M., at household No. 19 in list, was taken ill of scarlet fever on March 11th. After her brother's death, on February 1st, the family had gone to the seaside, and the house, during their absence, had been thoroughly fumigated and cleansed. On February 2nd Mr. M. himself was poorly for three days, and had enlarged glands in the neck, but no rash or sore throat; and while away from home his skin peeled profusely. His daughters, aged 13 and 3½, were much with him all the time. The family returned home on March 7th, and took Mr. V.'s milk from March 8th; the elder girl drank a good deal, the other only a little in tea and with porridge. On March 11th the elder girl was taken ill with an attack of scarlet fever, with a rash and slight desquamation; the other one had escaped up to the time of my visit, although equally exposed to infection from any other source but the milk.

2. Mr. S., at household No. 29, one not previously invaded, was a great friend of the last family; he met them on their return on March 7th, and was much with them up to March 10th. He had had V.'s milk from March 7th, but only took it in tea. On March 11th he was taken ill with "diphtheritic sore throat," without rash or subsequent peeling.

3. Mr. W., household No. 94, had suffered from sore throat in the previous outbreak, but in the meantime had recovered and "had never felt better in his life." He had had V.'s milk in tea and coffee since March 6th, and on March 9th he drank half a pint unboiled. On the evening of March 10th he had a slight sore throat, and on March 11th felt very ill, with shivering at night and difficulty in swallowing. On March 12th he was seen by a medical man, and had then a temperature nearly 104° F., and an inflamed sore throat of a dark port wine colour. Next day there was a greyish patch on one tonsil, and on the 21st there was slight albuminuria, which was noticed twice, and then disappeared. His son, who drank some of the milk unboiled on the evening of March 12th, had ear-ache and sore throat a day or two after.

4. At household No. 92, a servant had had sore throat in the previous outbreak, and had left. On March 6th another servant came from Staffordshire; she had been poorly for some time before with an "ulcerated throat," and vomited on her way to Macclesfield. Next day, however, she was better, and continued so until March 12th, when she again vomited, and next day had a sore throat. She had a severe illness, with a temperature reaching 103° F., and diphtheritic patches on the tonsils. She had taken V.'s milk since her coming, but only in tea. The two children, who were much with her, and also drank much milk, escaped; they had had scarlet fever in the previous year.

The history of the following household may be contrasted with the above:—

At household No. 34, Mrs. H. was taken ill on January 30th with sore throat and feverishness. She had been that day to see a relative (No. 75), whose servant was then ill with scarlet fever, having been one of the first cases (January 24th?). Mrs. H. had no deposit on the throat, and no rash. On February 1st, her baby, a year old, was taken ill with feverishness, sore throat, and swollen glands; it had a slight red rash, which soon disappeared, and was not followed by peeling. The servant and another child were sent away to another part of the town, where scarlet fever is not known to have existed;

they returned home on March 1st, the house having been disinfected. In this household V.'s milk was used up to January 31st, but had not been taken again. On March 9th the servant who had been away was taken ill with sore thoat; next day she had a scarlatinal rash, and was removed to the hospital; her skin afterwards peeled. On March 14th the boy had rash and enlarged glands, but not sore throat, and there has been no peeling. On March 12th the baby, who had been ill before on February 1st, was taken ill again with vomiting: a copious rash came out which lasted a week, and was followed by profuse peeling of the skin.

On the occurrence of fresh cases of illness among his customers coming to his knowledge, Mr. V., on March 13th, left off adding the milk of the cow which calved on January 20th to the general stock, and it has since then been given to the calf. In the early part of March some pimples or vesicles developed on one of the teats of this cow; and at the time that her milk was rejected scabs had formed on these. On my visit on March 25th there was a thin adherent scab, about the size of a sixpence, dark in the centre and light at the edge, near the lower part of one teat. The teat felt sticky when grasped, and the milk came less readily from it than from the others, having had to be drawn off that morning with a quill. The cow had lost flesh. The calf was healthy.

## ADDENDUM No. 1.

List of Customers of Mr. V.'s Dairy, showing Number of Inmates in each Household, the Delivery (Morning M., Night N.) which served, the Amount of Milk taken, and the Cases of Sickness occurring among them.

### A. In Upton.

| Households. | Inmates. | | Milk taken. | | | Cases of Illness. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | Children under 15. | Persons 15 years and upwards. | Delivery. | Usual daily Quantity (Pints). | Average daily Amount per Head (Pints). | Scarlet Fever. | Diphtheria. | Sore Throat. | |
| 1 | 3 | 3 | M. N. | 2 | ·33 | 1 | — | 1 | Milk delivered separately from farm. First case began Jan. 27. |
| 2 | — | 6 | M. N. | 4 and cream | ·67 | — | 1 | 4 | Fatal diphtheria. Patient largest milk drinker. |
| 3 | — | 5 | M. N. | 3 and cream | ·60 | — | — | 3 | Of two chief milk drinkers one had severe and one slight attack of sore-throat. |
| 4 | — | 5 | M. N. | 3 | ·60 | — | — | 2 | |
| 5 | 5 | 2 | N. | 1 | ·14 | — | — | 1 | |
| 6 | — | 3 | N. | 3 | 1·00 | — | — | — | All elderly. |
| 7 | 2 | 3 | N. | 2 | ·40 | 1 | — | 1 | |
| 8 | 3 | 5 | M. N. | 8 | 1·00 | 1 | — | 5 | Of the two who escaped one took no milk, the other only boiled. |
| 9 | — | 4 | M. | 2 | ·50 | — | — | 2 | Three milk drinkers, two attacked. |
| 10 | — | 3 | M. | 2 | ·67 | — | — | — | Milk not drunk. Chiefly used in puddings, &c. |
| 11 | 3 | 3 | M. N. | 4 | ·67 | 1 | — | 1 | Scarlatina patient had drunk much raw milk, also another child who escaped. |
| 12 | — | 5 | M. N. | 4 | ·80 | — | — | 3 | "Diphtheritic sore-throat." The three patients were chief milk drinkers. |



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| Households. | Inmates. | | Milk taken. | | | Cases of Illness. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | Children under 15. | Persons 15 years and upwards. | Delivery. | Usual daily Quantity (Pints). | Average daily Amount per Head (Pints). | Scarlet Fever. | Diphtheria. | Sore Throat. | |
| 13 | 3 | 5 | M. | 4 | ·50 | 3 | — | 1 | Scarlet fever cases began Jan. 25, 26, and 27. Children large milk drinkers. |
| 14 | — | 3 | M. N. | 3 | 1·00 | — | — | 2 | " Diphtheritic sore-throat. |
| 15 | — | 4 | M. N. | 2 | ·50 | — | — | 1 | |
| 16 | — | 3 | M. N. | 3 | 1·00 | — | — | 2 | One case began two days after leaving home. |
| 17 | — | 4 | M. N. | 3 | ·75 | — | — | 1 | |
| 18 | — | 6 | M. N. | 4 | ·67 | — | — | — | Milk all boiled. |
| 19 | 2 | 6 | M. N. | 8 | 1·00 | 1 | — | — | Fatal case; large milk drinker. |
| 20 | — | 1 | N. | ⅓ | ·33 | — | — | — | |
| 21 | — | 2 | N. | ⅔ | ·33 | — | — | — | |
| 22 | 2 | 2 | N. | 2 | ·50 | — | — | 1 | Patient drank less milk than others, but liable to sore-throat. |
| — | 23 | 83 | 16 19 | — | — | 8 | 1 | 31 | |

## B. In Macclesfield Borough.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 23 | — | 3 | M. | 2 | ·67 | — | — | — | |
| 24 | — | 5 | M. N. | 3 | ·60 | — | — | 1? | "Mumps." |
| 25 | 1 | 4 | M. | 2 | ·40 | — | — | — | |
| 26 | 1 | 5 | M. N. | 3 | ·50 | — | — | — | |
| 27 | 3 | 3 | M. N. | 4 | ·67 | 2 | — | 1 | |
| 28 | 2 | 3 | M. N. | 3 | ·60 | 1 | — | 3 | Scarlet fever patient had previous attack a year before. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 29 | — | 4 | M. | 1 | ·25 | — | — | — | |
| 30 | — | 4 | N. | 2 | ·50 | — | 1 | 1 | Diphtheria patient drank most milk, had "diphtheria" in infancy when others had scarlet fever, liable to sore throat. |
| 31 | 3 | 2 | M. N. | 7 | 1·40 | 2 | — | 1 | The child who escaped had boiled milk only, and had two meals daily away from home. |
| 32 | 18 | 6 | M. N. | 18 | ·75 | 5 | — | — | Scarlatina cases at once removed: six of those under 15 who escaped had had scarlatina previously. |
| 33 | — | 8 | M. | 2 | ·25 | 1 | — | 2 | |
| 34 | 2 | 4 | M. N. | 6 | 1·00 | 2 | — | — | |
| 35 | — | 3 | M. | 1 | ·33 | — | — | — | |
| 36 | — | 3 | M. | $\frac{2}{3}$ | ·22 | — | — | — | |
| 37 | 2 | 2 | M. N. | 3 | ·75 | 1 | — | — | Other child protected by previous attack of scarlet fever. |
| 38 | — | 5 | M. N. | 2 | ·40 | 1 | — | — | Three protected by previous attacks. |
| 39 | 2 | 2 | M. | 1 | ·25 | 3 | — | — | Fatal case of scarlet fever. |
| 40 | 6 | 4 | M. N. | 8 | ·80 | 1 | — | 5 | Three children protected by previous scarlatina. |
| 41 | 4 | 3 | M. | 1 | ·14 | — | — | 1 | |
| 42 | 1 | 2 | N. | 2 | ·67 | — | — | 1 | |
| 43 | 1 | 3 | N. | $\frac{1}{3}$ | ·08 | — | — | — | |
| 44 | 4 | 2 | N. | 1 | ·17 | — | — | — | |
| 45 | 4 | 5 | M. N. | 1 | ·11 | 1 | — | 2 | The four children escaped and were sent away at once, two of them were protected by previous attacks, and the other two drank little milk. |
| 46 | — | 2 | M. | 1 | ·50 | — | — | 1 | |
| 47 | — | 2 | M. | 1 | ·50 | — | — | — | |
| 48 | — | 5 | M. N. | 4 and cream. | ·80 | — | — | 4 | |
| 49 | — | 2 | M. | 1 | ·50 | — | — | — | |
| 50 | — | 2 | M. | 1 | ·50 | — | — | — | |
| 51 | — | 3 | N. | $2\frac{1}{3}$ | ·78 | — | — | — | |
| 52 | — | 4 | N. | 1 | ·25 | — | — | — | |
| 53 | 2 | 2 | N. | $\frac{2}{3}$ | ·17 | — | — | 1 | The children escaped; they drank chiefly milk obtained in the morning from another source. |
| 54 | 3 | 4 | N. | 1 | ·14 | — | — | — | Milk all boiled. |
| 55 | — | 5 | M. N. | 3 | ·60 | — | — | 2 | Those who escaped had milk boiled. |

On Scarlet Fever associated with Diphtheria and Sore Throat, at Macclesfield and Upton, in connexion with milk supply; by Dr. Parsons.

| Households. | Inmates. | | Milk taken. | | | Cases of Illness. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | Children under 15. | Persons 15 years and upwards. | Delivery. | Usual daily Quantity (Pints). | Average daily Amount per Head (Pints). | Scarlet Fever. | Diphtheria. | Sore Throat. | |
| 56 | 4 | 1 | M. N. | 1⅓ | ·27 | — | — | 1 | |
| 57 | — | 2 | N. | 1 | ·50 | — | — | — | |
| 58 | 1 | 3 | M. | ⅔ | ·17 | — | — | — | |
| 59 | 3 | 2 | M. | ⅔ | ·13 | — | — | 1 | |
| 60 | — | 2 | M. | ⅔ | ·33 | — | — | — | |
| 61 | — | 2 | M. | 1 | ·50 | — | — | — | |
| 62 | — | 4 | M. | 1 | ·25 | — | — | 1 | |
| 63 | — | 3 | N. | ⅔ | ·22 | — | — | 1 | |
| 64 | — | 3 | N. | 1 | ·33 | — | — | 2 | The one who escaped never took milk. |
| 65 | 1 | 2 | N. | ⅔ | ·22 | 1 | — | — | |
| 66 | 1 | 3 | M. | ⅔ | ·17 | — | — | — | |
| 67 | — | 2 | M. | ⅓ | ·17 | — | — | — | |
| 68 | 3 | 4 | M. | 1 | ·14 | — | — | — | |
| 69 | not ascertained | | M. | 1 | — | — | — | — | |
| 70 | 2 | 3 | M. N. | 4 | ·80 | 1 | — | — | Patient chief drinker of raw milk. |
| 71 | 5 | 2 | N. | 1 | ·14 | — | — | — | |
| 72 | 4 | 4 | M. N. | 4 | ·50 | — | — | 6 | Two adults escaped; one drank little milk, the other was much away from home. |
| 73 | 6 | 2 | M. N. | 4 | ·50 | — | — | — | |
| 74 | 1 | 6 | M. N. | 2 | ·28 | — | — | — | |
| 75 | — | 2 | M. N. | 2 | 1·00 | 2 | — | — | Much milk drunk raw by both. |
| 76 | 3 | 4 | M. | 2 | ·28 | 2 | — | 1 | The scarlet fever patients were the only ones in the house who liked cold milk. |
| 77 | 5 | 2 | M. | 1 | ·14 | — | — | — | |
| 78 | 4 | 3 | M. N. | 3 | ·43 | 2 | — | 1 | Chief milk drinker drank it only boiled, and escaped. |
| 79 | — | 2 | M. | ⅔ | ·33 | — | — | 2 (?) | |
| 80 | — | 4 | M. | 1⅓ | ·33 | — | — | 1 | Patient drank most milk of anyone in the house. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 81 | — | 2 | M. | $\frac{1}{3}$ | ·17 | — | — | 1 | |
| 82 | — | 2 | M. N. | 4 | 2·00 | — | — | 2 | Both large milk drinkers. |
| 83 | 1 | 4 | N. | 1 | ·20 | — | — | — | |
| 84 | — | 4 | M. N. | 3 | ·75 | — | — | 1 | |
| 85 | — | 10 | M. N. | 6 | ·60 | 1 | — | 1 | |
| 86 | — | 4 | M. | $\frac{2}{3}$ | ·17 | — | — | — | |
| 87 | — | 5 | M. | $\frac{2}{3}$ | ·13 | — | — | 1 | |
| 88 | — | 1 | M. | $\frac{1}{3}$ | ·33 | — | — | — | |
| 89 | 1 | 3 | M. | $\frac{2}{3}$ | ·17 | — | — | — | |
| 90 | 1 | 3 | M. | 1 | ·25 | — | — | 1 | |
| 91 | 1 | 1 | M. | $\frac{1}{4}$ | ·12 | — | — | — | |
| 92 | 2 | 3 | M. N. | 3 | ·60 | — | — | 1 | Children protected by previous attacks of scarlet fever. |
| 93 | 7 | 4 | M. N. | 4 | ·36 | — | — | — | |
| 94 | 3 | 3 | N. | 1 | ·17 | — | — | 1 | Patient only one who drank milk unboiled. |
| 95 | — | 3 | N. | 1 | ·33 | — | — | — | Milk all boiled. |
| 96 | 4 | 6 | M. N. | 2 | ·20 | — | — | — | |
| 97 | — | — | M. N. | 2 | — | — | — | — | Removed. |
| 98 | — | 5 | M. | 1 | ·20 | — | — | — | |
| 99 | 3 | 3 | M. | $\frac{2}{3}$ | ·11 | — | — | — | |
| 100 | 2 | 2 | M. | 1 | ·25 | 1 | — | — | |
| 101 | — | 2 | M. | 1 | ·50 | — | — | — | |
| 102 | — | 6 | M. | 1 | ·17 | — | — | — | |
| 103 | — | — | M. | $\frac{2}{3}$ | — | — | — | — | Removed. |

N.B.—The households up to about No. 69 are arranged as nearly as possible in the order in which they were visited; but after that point the morning and evening order differed, the latter part of the round being taken in the reverse direction in the evening to what it was in the morning. The latter part of the list follows most nearly the evening order. Besides the above regular customers, a few odd pennyworths were occasionally sold on the road.

App. A. No. 12.

On Scarlet Fever associated with Diphtheria and Sore Throat, at Macclesfield and Upton, in connexion with milk supply; by Dr. Parsons.

## ADDENDUM No. II.

A.

Dear Sir, Stockport, 4th February 1889.

I have analysed the water brought by you on February 2nd, and find it to be a very bad water, as the following results indicate:—

| | |
|---|---|
| Chlorine, per gallon - - | 17·5 grains. |
| Free ammonia - - - | 0·96 parts per million. |
| Albuminoid ammonia - - | 0·90 ,, ,, |

These results point unmistakably to sewage contamination, and show that the water is totally unfit for drinking purposes.

Yours sincerely,
(Signed) Geo. Davies, F.C.S.

Dr. Somerville.

B.

Bankfield, The Cliffe,
Higher Broughton,
Manchester,
March 2nd, 1889.

Dear Sir,

I enclose the analyses of two waters, Nos. 1 and 2.

| | 1. (Water from Spring at Mr. V.'s Farm.) | 2. (Water from Pump at ditto.) |
|---|---|---|
| Appearance in tube - - - - | Very clear | Cloudy |
| Total solids at 212° F. - - - | 14 | 61 |
| ,, ,, after ignition - - - | 11 | 49 |
| Chlorine - - - - - | 0·9 | 6·4 |
| Oxygen required for 15 minutes - - | ·008 | ·025 |
| ,, ,, ,, 3 hours - - | ·022 | ·028 |
| Free ammonia in one million - - | ·01 | ·16 |
| Albuminoid ,, ,, - | ·12 | ·12 |

No. 1, I consider to be a good water, but No. 2 I cannot call a sample of first-class water, but should look upon it as a water of doubtful purity. This water is contaminated with vegetable matter, and this water is not one I should recommend for the supply of a large town. This water can be used for domestic purposes if no better can be procured.

I remain,
Yours truly,
J. L. Rushton, Esq., M.D. (Signed) J. Carter Bell.

N.B.—Mr. Bell has omitted to state on what scale his results, other than the amounts of free and albuminoid ammonia, are expressed, but grains per gallon are probably meant. Thus interpreted, his figures in the case of No. 2 are much lower than those given by Mr. Davis for another sample of water from the same source: if on any other customary scale, as parts per 100,000, or per million, the difference would be greater still. But even on Mr. Bell's figures for No. 2, I should be inclined to go farther than he does, and say that his results point unmistakably to sewage contamination; especially when I learn that No. 2 was taken from a spring issuing within a few hundred yards of the well from which No. 1 was drawn, and probably from the same strata.

H. F. P.

## ADDENDUM No. III.

App. A. No. 12.

On Scarlet Fever associated with Diphtheria and Sore Throat, at Macclesfield and Upton, in connexion with milk supply; by Dr. Parsons.

1, South Street, Nantwich Road,
Crewe,
February 16, 1889.

Sir,

I have the honour to report that on receipt of communications from your Clerk and Medical Officer of Health, I attended at Macclesfield on the 7th instant, for the purpose of rendering my assistance as a veterinary surgeon in the investigations relating to the outbreak of scarlatina and diphtheria prevailing in Macclesfield and its neighbourhood. And having received information that in a certain district the fever attacks had occurred almost without exception among persons who had consumed milk supplied from Mr. W. V.'s dairy at Upton, I proceeded, in company with Dr. Rushton, Dr. Bower, and Mr. Beard, V.S., to Mr. V.'s farm, and being informed by him that a portion of his milk supply had been obtained from the dairies of Mr. J. L., Yew Tree Farm, Upton, and Mr. S. W., Fallibroome Farm, I visited their premises and milking cattle also.

Mr. V.'s farm comprises 35 acres, and in his shippons I found 14 cows, all of which were apparently in good health and condition; their skins and udders were free from suspicious eruptions; the temperature of each cow (ascertained with the thermometer) did not exceed the normal height; their food was of good quality; their drinking water (samples of which were said to be undergoing examination by the county analyst) had no suspicious appearances; the house and premises were in a condition of cleanliness creditable to the occupier; and the general sanitary surroundings as presented to my notice were satisfactory.

Mr. L.'s farm contains 27 acres, and on his premises I found six cows, one of which had aborted six weeks previously. I took the temperature of each animal, and I found it normal. No symptoms of febrile disease nor suspicious looking eruptions on the skin and udder were discoverable.

Mr. L. stated that he had supplied Mr. V. with milk for four or five weeks on Sundays *only*, and that the last lot supplied was delivered on January 27th last, 11 days before my visit.

Mr. W.'s farm has an extent of 107 acres, and his shippons contained 22 cows besides young stock, none of which presented symptoms of any infectious disease. The last lot of milk supplied from this farm to Mr. V. was delivered, it is stated, on November 30th last, that is upwards of eight weeks before the reported occurrence of the first case of scarlatina in the present outbreak. Mr. W. informed me that he had also been supplying about 12 quarts of milk daily to Mr. Fisher, 12 quarts daily to Mr. Whittaker, and 3 quarts daily to Mr. Shaw, and it was alleged that no persons who had partaken of this milk were attacked with fever.

In my opinion, the cattle I examined on the farms I have named, and the milk *as drawn from the udder*, were free from all diseases capable of causing scarlatina and diphtheria in the human subject, and unless the milk became contaminated after its withdrawal from the udder, it could not possibly disseminate either of those forms of disease. There does exist, no doubt, the possibility that in various modes and at different places during the period elapsing between its abstraction by the milker and its consumption by the public, the milk may have become contaminated by contact with the infective germs of fever; but at present, the evidence in my possession with regard to its possible sources of infection, and the results of its consumption in the persons who partook of it, is not sufficient to enable me to express an opinion as to whether it *did* become infected or not. It is, however, very certain that contagious diseases may be disseminated by the agency of infected milk. (And here I beg to remark parenthetically, that suspected milk if used for human consumption should be boiled, in order to destroy any infective germs that may be present in it.)

App. A. No. 12.

On Scarlet Fever associated with Diphtheria and Sore Throat, at Macclesfield and Upton, in connexion with milk supply; by Dr. Parsons.

During an experience of over 30 years among the dairy stocks of Cheshire and adjoining counties, I have never seen or heard of cattle being attacked with infectious scarlatina, or with any other disease capable of communicating scarlatina to man.

* * * * *

I have the honour to be, Sir,
Your obedient servant,
Walter Lewis, M.R.C.V.S.,
Chief Veterinary Inspector of Cheshire,
Provincial Veterinary Surgeon to the Royal Agricultural Society of England, &c.

To the Chairman of the
Macclesfield Rural Sanitary Authority.

## No. 13.

### Report on Epidemic Prevalence of Measles in the Staffordshire Potteries in 1888–89; by Mr. John Spear.

During the latter part of 1888 and the spring of 1889 the attention of the Board was directed from time to time to the fatal prevalence of measles in the Potteries. Official representations were made on various occasions by the Sanitary Authority of Hanley, the central town of the Potteries, and apparently the centre of the epidemic, and by certain educational bodies of that town, on the subject of the closing of the elementary schools, and advice on this subject was asked of the Board by the Education Department. Reports also appeared in the public press as to the excessive fatality of the disease; a fatality, it was said, in which adults were sharing almost equally with children. The latter statement, if true, was calculated to suggest doubt as to the very nature of the disease reported to be prevailing, for in this country a high adult fatality from measles is unknown. In any case, whether the disease was measles or not, the Board desired to know further the circumstances of an undoubtedly most serious visitation; and especially the part that schools—a disputed point—had played in it. I accordingly received instructions to make inquiry in Hanley, and, incidentally, if necessary, in neighbouring places.

At the time of my visit, the end of May, the epidemic prevalence of the disease had practically ceased, although a few cases still continued to come under observation, both in Hanley and in certain neighbouring districts. I found the statement as to considerable adult fatality to be incorrect. The disease was true measles. The histories of cases, and those, the remains of the epidemic, that I saw myself, left no doubt of this. It seemed, however, probable that a certain number of cases of rötheln had occurred. I heard, for example, of two convalescents from measles suffering from attacks that in their mode of invasion, &c., were indicative of that affection; but speaking of the epidemic as a whole, it was one of true measles. The special type is a consideration that may conveniently be left for later discussion.

As to the prevalence of the disease in the Potteries and neighbouring districts of North Staffordshire, the returns as to measles mortality from the various Registration Sub-districts give the following information:—

## Table 1.

| Registration District. | Sub-District. | Population (1881). | Measles Mortality. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Total Number of Deaths, April 1888–June 1889. | Death Rate per 1,000 (of Population of 1881). | Deaths in 1888. | | | Deaths in 1889. | |
| | | | | | 2nd Quarter. | 3rd Quarter. | 4th Quarter. | 1st Quarter. | 2nd Quarter. |
| Stoke-upon-Trent | 1. Hanley | 26,089 | 144 | 5·5 | — | 1 | 80 | 33 | 30 |
| | 2. Shelton | 28,196 | 175 | 6·2 | — | 8 | 115 | 29 | 23 |
| | 3. Stoke | 17,272 | 62 | 3·6 | — | 14 | 44 | 3 | 1 |
| | 4. Fenton | 14,136 | 84 | 5·9 | — | 8 | 75 | — | 1 |
| | 5. Longton | 18,620 | 10 | 0·5 | — | 2 | 5 | 1 | 2 |
| Wolstanton | 1. Wolstanton | 17,501 | 24 | 1·4 | — | — | 18 | 4 | 2 |
| | 2. Tunstall | 29,675 | 55 | 1·8 | — | 15 | 29 | 9 | 2 |
| | 3. Burslem | 28,249 | 169 | 6·0 | — | 4 | 153 | 8 | 4 |
| Newcastle-under-Lyme | 1. Whitmore | 1,084 | 1 | 0·9 | — | — | — | — | 1 |
| | 2. Newcastle | 20,998 | 60 | 2·9 | — | — | 28 | 12 | 20 |
| | 3. Audley | 12,579 | 36 | 2·9 | — | 2 | 13 | 21 | — |
| Leek | 1. Norton | 10,430 | 38 | 3·6 | — | — | 16 | 22 | — |
| | 2. Leek | 20,718 | 2 | 0·1 | — | — | 1 | 1 | — |
| | 3. Leek Frith | | | | | | | | |
| | 4. Longnor | | | | | | | | |
| Cheadle | 1. Alton | 15,564 | 9 | 0·5 | 2 | 1 | 2 | 1 | 3 |
| | 2. Ipstones | | | | | | | | |
| | 3. Dilhorne | | | | | | | | |
| | 4. Cheadle | 7,160 | 11 | 1·5 | 11 | — | — | — | — |

The chief towns comprised in these districts are shown in the tabular statement below. The first six are the centres of the Staffordshire earthenware and porcelain manufacture. They constitute an almost continuous line of populous districts extending some seven miles along the valley traversed by the North Staffordshire Railway, the Mersey and Trent Canal, and by tributaries of the Trent. Geologically, they occupy a large part of the North Staffordshire Coal-field. Newcastle-under-Lyme is situated a little to the west of this line, and mainly upon the Permian beds.

Table 2.

| Towns. | Population (estimated). | Measles Mortality per 1,000 (July 1888—May 1889). | Number of Deaths from Measles. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1888. | | | | | | | | 1889. | | | | |
| | | | 1st Qr. | 2nd Qr. | July. | August. | September. | October. | November. | December. | January. | February. | March. | April. | May. |
| Hanley - | 56,000 | 4·9 | — | — | 1 | 1 | 2 | 57 | 70 | 48 | 38 | 10 | 8 | 31 | 9 |
| Stoke - - | 21,000 | 3·3 | 1 | — | 2 | 5 | 13 | 26 | 18 | 1 | 2 | 1 | — | 1 | — |
| Fenton - - | 15,500 | 5·7 | — | — | — | 1 | 8 | 41 | 33 | 5 | 1 | — | — | — | — |
| Longton - | 35,000 | 0·5 | — | 1 | 1 | — | 2 | 3 | 3 | 1 | 1 | — | 1 | 1 | 3 |
| Tunstall - | 14,600 | 1·9 | — | — | — | 7 | 6 | 10 | 2 | 1 | 2 | — | — | — | — |
| Burslem - | 26,000 | 5·8 | — | — | — | — | 2 | 52 | 70 | 18 | 5 | -- | — | 2 | 2 |
| Newcastle - | 19,400 | 2·9 | — | — | — | — | — | 5 | 9 | 19 | 5 | 3 | 3 | 7 | 5 |

## I.—*Prevalence of Measles in Hanley.*

In the middle of October 1888, when the disease became seriously prevalent in Hanley, the Sanitary Authority offered a fee to medical men for information of first attacks in families, and shortly afterwards two assistant sanitary inspectors were temporarily appointed to make house-to-house visitation, and to take note of houses infected since the commencement of the epidemic. By these means a large proportion, no doubt, of family invasions came under the notice of the sanitary department of the district.

The total number of infected houses reported was 1,341. No complete list of *cases* was obtained, and an estimate only of their approximate number can be given. Taking an average of two cases in each infected family (the ascertained average in a number of instances) and making some allowances for unavoidable incompleteness in the list of family invasions, the total number may be estimated at about or somewhat over 3,000.

As will already have been gathered, Hanley was not the first of these North Staffordshire districts to be invaded by the epidemic, and other towns—Fenton and Burslem, on either side—suffered even more severely. On the south, Cheadle (a rural village), Longton, Fenton, and Stoke were seriously infected before Hanley (although in Longton the mortality was comparatively insignificant); and, on the north, Tunstall, and probably Burslem. Hanley, standing as it were between two fires, was invaded, there is reason to believe, from opposite quarters.

The southern localities of Hanley (adjoining Stoke) were first seriously invaded, but the disease quickly appeared in the northern extremity (adjoining Burslem), and spread thence to intermediate points. The southern districts, while suffering the most at the commencement of the epidemic, in October and November, were notably less seriously implicated in the renewed outburst of the following spring.

In the table below I have shown the distribution of the deaths and of household invasions in the borough during the several months of epidemic prevalence. The School Board divisions have been taken for the purposes of this classification, partly because an estimate of the population therein could be based upon a recent enumeration of the children of

## Table 3, showing the Distribution of Measles in Hanley.

| School Board Divisions of the Hanley Urban Sanitary District. | In 10 Months, August 1888 to May 1889. | | | | | * Household Invasions (per cent.) in— | | | | | | | | | | Death Rates (per 1,000 of Population) in— | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated Population. | Total Number of Infected Houses. | Total Number of Deaths. | Household Invasions (per cent.). | Death Rate per 1,000 of Population. | 1888. August. | September. | October. | November. | December. | 1889. January. | February. | March. | April. | May. | 1888. August. | September. | October. | November. | December. | 1889. January. | February. | March. | April. | May. |
| Shelton - - | 10,866 | 337 | 80 | 17·2 | 7·4 | — | ? † | 10·0 | 4·0 | 1·2 | 0·7 | — | 0·6 | 0·5 | 0·2 | — | 0·2 | 3·5 | 2·5 | 0·5 | 0·2 | — | 0·1 | 0·3 | — |
| Cauldon Road - | 2,617 | 29 | 11 | 5·8 | 4·2 | 0·3 | ? † | 5·0 | 0·6 | — | — | — | — | — | — | 0·4 | — | 3·1 | 0·8 | — | — | — | — | — | — |
| Eastwood - - | 3,377 | 88 | 14 | 14·4 | 4·1 | — | — | 2·6 | 9·7 | 1·3 | — | 0·5 | 0·2 | — | — | — | — | 0·6 | 2·6 | 0·9 | — | — | — | — | — |
| York Street - | 11,030 | 307 | 75 | 15·4 | 6·8 | — | — | 1·5 | 3·3 | 1·6 | 3·0 | 0·6 | 0·4 | 4·3 | 0·8 | — | — | 0·6 | 1·1 | 0·5 | 2·1 | 0·5 | 0·3 | 1·4 | 0·4 |
| Northwood - | 11,666 | 293 | 61 | 13·9 | 5·2 | — | — | 1·1 | 4·4 | 3·4 | 0·9 | 0·5 | 0·7 | 2·0 | 0·9 | — | — | 0·1 | 1·0 | 1·9 | 0·5 | 0·4 | 0·1 | 1·0 | 0·2 |
| Etruria - - | 2,041 | 17 | 1 | 4·6 | 0·5 | — | — | 1·0 | 1·9 | — | 1·5 | 0·3 | — | — | — | — | — | — | — | — | 0·5 | — | — | — | — |
| Central - - | 14,373 | 270 | 32 | 10·4 | 2·2 | — | — | 1·0 | 2·8 | 2·8 | 0·9 | — | 1·3 | 1·1 | 0·4 | — | — | 0·1 | 0·6 | 0·8 | 0·3 | — | 0·2 | — | 0·1 |
| Whole District - | 56,000 | 1,341 | 274 | 13·1 | 4·9 | | | 3·0 | 3·7 | 2·0 | 1·2 | 0·3 | 0·7 | 1·6 | 0·5 | | | 1·0 | 1·3 | 0·9 | 0·7 | 0·2 | 0·1 | 0·6 | 0·1 |

* *i.e.*, first invasion of each house, as far as ascertained, *vide* penultimate paragraph, page .
† Information regarding the Shelton and Cauldon Road districts during the first week or two of the epidem ic was evidently incomplete.

school age, and partly because it may be inferred that, as a rule, the children of school age in these several divisions attended the schools situated therein or appointed for the purpose by the School Board; and the influence of school attendance was one of the points to which inquiry had to be directed.

I found it impracticable to obtain any trustworthy facts about the number of family invasions of measles that began with children under school-ages. I can only say that such information as was brought me by the assistant inspectors gave me the impression that such invasions were for the most part apparent rather than real; the child under school-age having in fact contracted the disease from some previous (but unrecorded) child who had fallen ill after attendance at a school, and who was living in the same or in an adjacent house.

[It has to be noted that, speaking generally, the cases are classified in this return according to the date at which they were reported, and this in the majority of cases would be some days later than the date of attack.]

The order and degree in which the schools in Hanley were affected by the growing prevalence of the disease may in a measure be estimated by the coincident falling off in school attendance. The following is the information obtainable under this head:—

STATEMENT showing the DIMINUTION per CENT. of the AVERAGE ATTENDANCE at the various HANLEY SCHOOLS during the Weeks preceding their closure, as compared with the usual average.

NOTE.—* indicates fair average attendance which could not be stated numerically.
— indicates closure of school.

SHELTON AND CAULDON ROAD SCHOOL DISTRICT.

| School. | Week ending— | | | | | | |
|---|---|---|---|---|---|---|---|
| | September. | | October | | | | November |
| | 21st. | 28th. | 5th. | 12th. | 19th. | 26th. | 2nd. |
| Wharf Lane Board: | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c |
| Girls - - | * | 15 | 22 | 20 | 30 | 35 | — |
| Infants - - | 10 | 56 | — | — | — | — | — |
| Cannon Street Board: | | | | | | | |
| Boys - - | * | * | * | 7 | 14 | 25 | — |
| Girls - - | * | * | * | * | 18 | 35 | — |
| Infants - - | * | * | * | 10 | 35 | — | — |
| Shelton Church: | | | | | | | |
| Boys - - | * | * | 5 | 6 | — | — | — |
| Girls - - | * | * | 6 | 18 | — | — | — |
| Infants - - | * | * | * | 29 | — | — | — |

App. A. No. 13.

On Epidemic Prevalence of Measles in the Staffordshire Potteries; by Mr. Spear.

## Eastwood School District.

| School. | Week ending— | | |
|---|---|---|---|
| | October | | November |
| | 19th. | 26th. | 2nd. |
| Eastwood Board | p. c. | p. c. | p. c. |
| Boys | * | 10 | — |
| Girls | * | 8 | — |
| Infants | * | 27 | — |

## York Street School District.

| School. | Week ending— | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | October | | November | | | | | December | | |
| | 19th. | 26th. | 2nd. | 9th. | 16th. | 23rd. | 30th. | 7th. | 14th. | 21st. |
| York Street Board: | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. |
| Boys | * | 10 | — | — | — | — | — | — | — | — |
| Girls | 7 | 6 | — | — | — | — | — | — | — | — |
| Infants | * | 15 | — | — | — | — | — | — | — | — |
| Catholic: | | | | | | | | | | |
| Boys | * | * | 18 | 18 | 27 | 27 | 23 | 21 | 27 | — |
| Girls | * | * | 10 | 15 | 25 | 25 | 27 | 30 | 32 | — |
| Infants | * | * | 9 | 14 | 18 | 20 | 24 | 25 | 42 | — |

## Northwood School District.

| School. | Week ending— | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | October | | November | | | | | December | | |
| | 19th. | 26th. | 2nd. | 9th. | 16th. | 23rd. | 30th. | 7th. | 14th. | 21st. |
| Broom Street Board: | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. |
| Boys | * | 4 | — | — | — | — | — | — | — | — |
| Girls | * | 9 | — | — | — | — | — | — | — | — |
| Infants | 6 | 22 | — | — | — | — | — | — | — | — |
| Northwood National: | | | | | | | | | | |
| Boys | * | * | * | 7 | 14 | 14 | 12 | 12 | 23 | — |
| Girls | * | * | * | 19 | 19 | 19 | 16 | 14 | 30 | — |
| Mixed | * | * | 13 | 38 | 40 | 40 | 53 | 58 | 73 | — |
| Infants | * | * | 30 | 37 | 43 | 40 | 42 | 32 | 50 | — |

## Central School District.

| School. | Week ending— October 19th. | October 26th. | November. 2nd. | 9th. | 16th. | 23rd. | 30th. | December 7th. | 14th. | 21st. |
|---|---|---|---|---|---|---|---|---|---|---|
| St. John's Church: | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. | p. c. |
| Boys | * | * | 7 | — | — | — | — | — | — | — |
| Girls | * | 5 | 8 | — | — | — | — | — | — | — |
| Infants | * | 6 | 12 | — | — | — | — | — | — | — |
| Wellington Church: | | | | | | | | | | |
| Boys | * | * | 8 | 15 | 22 | 10 | 8 | 10 | 14 | — |
| Girls | * | * | 5 | 20 | 28 | * | 6 | 8 | 17 | — |
| Infants | 12 | 10 | 8 | 10 | 13 | * | * | * | 13 | — |
| Wesleyan: | | | | | | | | | | |
| Boys | * | 6 | 10 | 17 | 27 | 10 | 10 | 13 | 25 | — |
| Girls | * | 10 | 16 | 36 | 38 | 23 | 23 | 23 | 38 | — |
| Infants | * | 7 | 16 | 30 | 40 | 30 | 28 | 35 | 50 | — |

The above series of figures not only show how closely and largely the growing prevalence of measles interfered with school attendance, but also that in the majority of cases the closure of the school was only effected after the disease had made great progress. In the infant schools, considering them collectively, the attendance during the week preceding closure in the several cases was reduced by 36 per cent. below the normal average, and if the last two days were regarded separately the percentage of deficiency would be found very much higher. As a matter of fact, the voluntary schools were, for the most part, only closed when it seemed to the managers no longer worth while to keep them open.

In the case of the Shelton and Cauldon Road School district (the one first infected) the figures create a strong suspicion also that the incidence of infection was largely determined by school attendance. In that district there are three schools, all situated within a radius of 200 yards. The average attendance in the infant department of one of them fell to less than half the normal in the last week of September, while in the same department of the other two a fair average was maintained for two weeks later.

I have endeavoured by means of diagrams which follow to examine the influence which the closure of the schools had upon the progress of the epidemic.

In reading these diagrams it has to be borne in mind that, as in Table 2, the date of family invasion represents in the majority of cases the date of its report; further, the date of *infection* would be, in the case of measles, some 14 days before that upon which the disease became developed. In the following diagrams, in representing the approximate rise and fall of *infection*, this period of incubation (14 days) has been allowed for.

Unfortunately for this method of examination, the closure of schools, except in the Eastwood district, was not, as will be seen, complete during the earlier and more acute periods of the epidemic; and, apart from this difficulty, the rule that children of school age attend the schools within the division in which they reside is one having many exceptions. The Wesleyan schools and the Catholic schools, for example, are attended by children from different divisions, and these remained open until a

late period. So far as the limited possibilities of the statistical method of examination go, it would appear that the closure of schools had a material influence in Hanley in controlling epidemic spread of the disease.

In the neighbouring towns the closure of schools was even less freely resorted to than in Hanley. At Burslem they remained open throughout the epidemic period; at Stoke-on-Trent only two schools, Boothen Church School and Hartshill Church School, were closed, and these only for three weeks; at Fenton all the elementary schools were closed, but only for 14 days, from October 29th to November 12th; at Newcastle, during the prevalence of the disease in 1888, only one school (the Friar's Wood Board School) was closed—from October 26th to December 10th.

The evidence obtained from individual schools, and the histories (as to first seizures, &c.) of family invasions, went strongly to show that the schools had been centres of infection. At two infant schools I was informed by the mistresses that many children had been sent home because it was obvious that they were suffering from the premonitory symptoms of the disease, in a few instances because of the actual appearance of the rash; in another school, although only six cases were known of amongst the pupils at the time of its closure, there occurred, it was said, as many as 60 cases within the next fortnight, that is to say, within the period of incubation.

Referring now to the sanitary condition of the schools and the amount of air space and ventilation provided—a most important point in considering their influence on the spread of infection—it is an admitted fact that school accommodation in Hanley is insufficient for the wants of the town; and the natural result has been considerable overcrowding. Most of the schools maintain an average attendance well up to, and some even beyond, the number of children allowed by the standard which contemplates an average of eight square feet of floor-space per head; and as attendance is, especially in the infant schools, very variable, it follows that in order to maintain this high average considerably closer packing than this of the children is from time to time required. The infant department of the Wharf Lane Board School affords accommodation for no more than 207 children, if eight square feet per head be given; and this computation makes no provision for teachers. I am informed that the average attendance for one quarter of a recent year was 212, and for the whole of 1888 the average was 183.

It is, however, in certain voluntary schools that the more serious overcrowding is observable. The infant schoolroom of the Shelton Church Schools affords accommodation for 93 at most, if eight square feet of floor space be allowed for each pupil. I was informed that on one occasion in the summer 140 children were present, and the attendance at the time of my visit was stated to be 120. Moreover, the room is ill-ventilated and is invaded by foul air from privies. Additional accommodation at these schools is now being provided, but the state of things here remarked upon has continued for years. In July 1882 the Inspector of Schools reported, "the infants are horribly overcrowded," and in December 1883, "the room is hopelessly overcrowded." The infant department of the Catholic school affords total accommodation for 149 children, allowing eight square feet to each, and making no provision for teachers; 185 are on the books, and the average attendance is over 150. In the large schoolroom, giving at the most floor space for 104 children (teachers being left out of the computation), 150 were

assembled at the time of my visit; the neighbouring class-room was, however, empty. The school buildings are much hemmed in by houses of a poor class, and the air around is contaminated by foul privies. As in certain other of the denominational schools, great coats, caps, &c., of the children were hung up in the schoolrooms.

In the boys' department of the Wellington Church Schools the maximum number of pupils that could be admitted if eight square feet of the total floor space were allotted to each is 123; there are 176 on the books, and the number present at the time of my visit was 135. In the infants' department also the average weekly number is occasionally a little in excess of that authorised by the standard, which means of course that at times (during fine days, and in the morning classes) a large excess is present. Moreover, the Wellington Schools are throughout most imperfectly ventilated, and the rooms were found to be exceedingly close. The window space is insufficient, and only a small portion is made to open. "Tobin" tubes had been provided in the girls' and in the infants' schoolrooms; but those in the former had been permanently blocked up, whilst the others were too small and were apparently inactive through accumulated dust. This last-named defect, the impairment, through inattention, of the means provided for the introduction of air, was common I found in most of the schools in Hanley—the Board Schools as well as others.

Apart from the schools, many of the private houses invaded were well calculated to become most active centres of infection. Sick children were usually nursed in the living room of the family, and neighbours, often with children in their arms, freely congregated there. Little shops for the sale of provisions, &c., were kept open while sufferers from the disease lay in adjoining rooms. In fact, except for the tardy and often incomplete closure of the schools, little that could be called of real effect in controlling the spread of infection was attempted; or was, it may be said, practicable under the circumstances of life of the Pottery population.

## II.—*The Fatality of the Epidemic.*

In the several matters hitherto dealt with the experience of Hanley would probably find its counterpart in most widespread epidemics of measles affecting urban populations; but in respect of the fatality of the disease the experience was unusual. It has been estimated that the number of cases in Hanley did not far exceed 3,000; and upon this estimate the fatality, equal to 9 per cent., or rather more, of those attacked, was enormous for measles.

Careful study of the evidence obtainable brings into relief three possible and perhaps mutually contributory factors in the production of this excessive fatality. I will discuss them one by one in the following order—the type of the prevailing disease, the meteorological conditions at the time prevailing, the predisposition of the infant population to fatal illness. It will then perhaps be possible to form a judgment as to their relative importance.

So far as clinical observation showed, the type of the prevailing disease differed only from the normal in presenting some unusual general severity of the ordinary symptoms of measles. The fever was high; the eruption generally profuse and vivid, and the implication of the mucous membranes of the air passages and of the conjunctivæ, severe. True hæmorrhagic cases were not heard of, although the

eruption was sometimes spoken of as livid, discoloured, or purplish. Aphthous ulceration in the mouth was observed in some cases, and, in a few more, considerable ulceration; otherwise the mucous membrane of the digestive tract was seldom involved, and diarrhœa was uncommon. Convulsions were apparently somewhat apt to occur in very young subjects. Occasionally cases of measles were met with amongst relatives and neighbours that appeared to be as a group characterised by exceptional severity and by early death, but more often severe cases and others of moderate severity were seen side by side. Slight, inconspicuous cases were, it seemed, relatively rare, at least during the early stages of the epidemic; as the spring advanced they became, it was believed, more common.

The attacks were distributed in exactly equal proportion between the two sexes. As to age, the classification of the deaths is as follows:—Under 1 year, 59; 1 to 2 years, 96; 2 to 4 years, 78; 4 to 8 years, 36; above 8 years, 5.

From the medical certificates of death certain particulars as to the course of the fatal attacks, and the immediate cause of the fatal issue, may be gathered. These particulars are subjoined.

| | | |
|---|---|---|
| Deaths registered from "measles," "morbilli," or "rubeola," simply | | 82 |
| ,, | measles and lung complications (bronchitis or pneumonia) | 137 |
| ,, | measles and laryngitis | 6 |
| ,, | rötheln, with bronchitis or pneumonia | 10 |
| ,, | measles and convulsions | 19 |
| ,, | rötheln and convulsions | 4 |
| ,, | measles and meningitis | 7 |
| ,, | ,, and cancrum oris | 1 |
| ,, | ,, and stomatitis | 1 |
| ,, | ,, and abscess | 1 |
| ,, | ,, and dropsy | 1 |
| ,, | ,, and albuminuria | 1 |
| ,, | ,, and diarrhœa | 1 |
| ,, | ,, and pertussis | 1 |
| ,, | rötheln and marasmus | 2 |
| ,, | ,, and diphtheria | 1 |
| | | 275 |

The duration of the illness was stated in the medical certificate in only 61 instances; but this, amongst other information, was obtained subsequently in the great majority of cases. In 23 per cent. of these, death was stated to have occurred during the first week of illness; in 40 per cent. during the second week; in 25 per cent. during the third, and in 12 per cent. at a later period.

So far as I was able to inquire into the behaviour of the disease in neighbouring districts in which fatal epidemicity occurred, no very notable departure was there observed from the experience recorded above. A comparative statement as to the frequency of lung complication as a cause of death, and as to the age at death, is subjoined:—

Table 4.

| District. | No. of Deaths. | Per-centages of Deaths ascribed to Lung Complications. | Per-centage of Deaths at various Ages. | | | | |
|---|---|---|---|---|---|---|---|
| | | | Under 1. | 1-2. | 2-4. | 4-8. | 8 and over. |
| Hanley - - | 275 | 54 p.c. | 22 | 35 | 28 | 13 | 2 |
| Burslem - - | 151 | 55 p.c. | 25 | 35 | 29 | 11 | 0 |
| Fenton - - | 89 | 80 p.c. | 19 | 38 | 31 | 12 | 0 |
| Tunstall - - | 28 | 62 p.c. | 25 | 39 | 23 | 13 | 0 |
| Newcastle - - | 56 | 2 p.c. | 17 | 41 | 31 | 10 | 0 |

*Note.*—At Tunstall, where the epidemic was somewhat earlier than in the other towns, being practically over by the end of October, the disease showed much less fatality than in the other Pottery towns mentioned above (*i.e.*, those exclusive of Newcastle). The same observation applies to Longton, and in a less degree to Stoke (*vide* Table 2).

At Hanley and Burslem no greater fatality from lung complications was recorded during midwinter than in other months of the epidemic prevalence. The per-centage of such deaths to the total number, during November and December alone, was in these towns 51 and 55 respectively.

In the English Registrar General's Returns it appears that, in 10 years 1871-80, of 91,948 deaths from measles at all ages, 21 per cent. were of infants under one year, and 59 per cent. of children under two years of age.

As to concurrent meteorological conditions, a weekly record of deaths, together with the mean readings of the thermometer and barometer, and the amount of rainfall, are shown in the diagram opposite [*not here reproduced*].

That a low temperature should exercise a certain unfavourable influence on the frequent pulmonary complications of measles, especially amongst the poor, where efficient means of nursing are wanting, is to be expected, and certain experiences in this North Staffordshire epidemic, notably the experience of Longton, where wide prevalence of the disease in the summer caused only very slight mortality, suggest that had Hanley been invaded at another period of the year, the result, as regards mortality, might have been far different from what actually obtained. In considering, however, the sufficiency of this factor of unfavourable weather, it has to be noted that neither the summarized weekly comparison of deaths and meteorological conditions, nor the daily record which I have had an opportunity of studying, can be said to afford indications of any close connexion, at any rate, between varying fatality and varying temperature, or such other meteorological conditions as are recorded. Further, it has already been noted that the proportion of deaths ascribed to *lung complications* did not materially vary in the several months, of varying temperature, of the epidemic prevalence; and then, again, the fact that winter epidemics of measles are not unfrequently unattended with any great fatality has to be borne in mind. Such considerations must tend to reduce our estimate of the sufficiency or importance of this meteorological factor. Perhaps a special disposition to severe pulmonary complications, either resulting from the type of the prevailing disease, or peculiar to the population attacked, is wanting to give to low temperature that potency for mischief which it appears only in a general sense, and occasionally, to possess. In a general and incidental way winter weather doubtless exerted an influence on the fatality of the Hanley epidemic.

Coming now to the question of susceptibility, the case of Hanley is certainly not one of those in which severe epidemics have followed long continued immunity from the disease. On the contrary, epidemics of measles have followed each other in somewhat quick succession, and the mortality has been for many years above the average of the country. In the 10 years 1851–60, the annual average death-rate from measles in the Stoke registration district (in which Hanley is situated) was 3·8 per 10,000 of the population; the corresponding rate in England and Wales was 2·8. In the following decennium the rate in the registration district was 6·2; in England and Wales it was 3·8. In 1871–80 the corresponding average in the registration district was 4·9; in England and Wales it was 3·7. During the seven succeeding years, 1881–1887, the deaths in the borough numbered respectively, 21, 1, 52, 4, 54, 29, and 42. The average annual rate was 5·7 per 10,000 of the estimated population.

As to any special predisposition of the population of this district to *fatal* attacks: Amongst the medical men of the town there was a consensus of opinion that children of debilitated constitution succumbed to the disease much more readily than the previously strong and healthy. From this evidence,—and it is in accord with general experience,—the problem of the high fatality would seem largely to resolve itself into one of the general condition, as regards health, of the youthful population. Here, as elsewhere, some 85 per cent. of the deaths were of infants under four years of age.

Now, one of the most striking features in the sanitary history of Hanley is the persistent high general mortality amongst young children. During the 11 years 1877–87, the average annual infant mortality, measured by the proportion of deaths under 1 to the number of births registered, was 194 per 1,000; in England and Wales the corresponding average was 142 per 1,000, and in London 154. Of children under five years in Hanley, the mean death rate, per 1,000 estimated to be living at that age, was 70·4 for the five years 1883–1887. In England and Wales the corresponding average rate was 55·0.*

* The yearly rates in Hanley (as given in the Reports of the Medical Officer of Health) were as follows:—

Deaths under 1 to 1,000 Births registered.

| 1877. | 1878. | 1879. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 193 | 172 | 214 | 192 | 179 | 206 | 203 | 191 | 198 | 199 | 184 | 193 |

Death-Rate of Children under 5 per 1,000 estimated to be living at that age (the latter estimate being based upon the proportional age constitution of the population at the time of the last census).

| 1883. | 1884. | 1885. | 1886. | 1887. | 1888. |
|---|---|---|---|---|---|
| 86·6 | 70·5 | 65·6 | 68·4 | 61·0 | 74·1 |

[A report dealing with the mortality amongst Potters and in Pottery districts was made by Dr. Greenhow, acting under orders of the Privy Council, in 1860; and in 1872 Dr. Ballard, in his report of an inspection of Hanley, treats of the same subject, referring to the high infant mortality, "especially from diarrhœa, brain disease, scarlatina, and measles." These reports are, however, before the Board.]

In 1863 the cause of the excessive mortality amongst children in the Stoke registration district (which comprises Hanley) was discussed by Dr. Arlidge, senior physician to the Stoke-on-Trent Infirmary, in a valuable paper, entitled "The Sanitary State of the Staffordshire Potteries," published in the "Medico-Chirurgical Review" for July of that year. The rates of mortality, generally, have fallen since that date; but they still remain largely in excess of the average of the country, and the excess is still noticeable in the same class of diseases. I may, therefore, in this connexion, bring Dr. Arlidge's observations under the notice of the Board. He says:—

"The first fact to be taken into consideration is the enormous mortality of children in pottery towns. I have carefully analysed the registers of deaths in 1862, in Stoke parish, which had, in 1861, 71,308 inhabitants, and find that 616 deaths occurred under the first year and 498 at one year old and under five, which, relatively to the number of children, viz., 2,437 and 8,031 respectively, of the same ages living, represent a death-rate of 25·27 per cent. for those of the former, and 6·20 for those of the latter period of life. In other words, one-fourth of the whole number of children born perished within a year of their birth. In England, at large, this death-rate is 17·73 per 100; consequently, that in Stoke is nearly half as much again, and the deaths among infants, instead of numbering 616, should not have been more than 430, at the average of the whole country.

"The proportion of deaths of children under five years of age has exhibited a similar high range to the whole mortality of the district. In Wolstanton parish, in 1857, the deaths under five years of age were 645 of the whole number, 1,217, or 52·99 per cent., and in 1861 were 588 of 1,159, or 50·73 per cent. Likewise in Stoke parish the deaths under five were in the former year 40·23, and in the latter, 50·22 per cent. of the whole mortality, and again, in 1862, 49·86 per cent. The fact is, therefore, that one-half of the entire number of deaths, in any one year, occur among children under five years of age, and upwards of one-fourth among those under one year old.

"An inquiry into the causes of this excessive mortality of young children exhibits the result shown in the following table:—

Deaths of those under Five Years Old to Number Living.

| Population in Stoke under Five Years, 10,468. | | | Population in England under Five Years, 2,700,782. | | |
|---|---|---|---|---|---|
| Cause of Death. | No. of Deaths. | Ratio to 100,000 living. | No. of Deaths. | Ratio in 1861 to 100,000 living. | Average Ratio for Ten Years to 100,000 living. |
| Diseases of lungs - | 210 | 2,000 | 29,449 | 1,090 | 1,040 |
| Consumption - | 50 | 477 | 3,052 | 113 | |
| Zymotic diseases - | 265 | 2,531 | 53,654 | 1,986 | |
| Convulsions - | 282 | 2,693 | 29,291 | 1,084 | |
| Cerebral diseases - | 49 | 486 | 3,208 | 118 | |

"The most prominent facts seen in this table are the great mortality of such young children in Stoke parish from each of the groups of causes tabulated, and especially from lung diseases and consumption together, and from convulsions and cerebral diseases. The ratio of deaths from consumption and from cerebral disease is above four times that found in all England, and that of those from convulsions more than twice.

"With reference to the whole mortality in Stoke in 1862, viz., 2,107 deaths at all ages, 260 occurred among children under five years of age from diseases of the chest and consumption, or 12·37 per cent.; 295 from zymotic diseases, or 14·00 per cent.; 178 from marasmus, debility, atrophy, and tabes mesenterica, or 8·44 per cent.; 49 from cerebro-spinal disease, or 2·32 per cent.; 282 from convulsions and teething, or 13·37 per cent.; and 80 from all other causes, or 3·79 per cent.

"The destruction of infantile life by diseases of the strumous class, as represented by a majority of the deaths assigned to marasmus, tabes mesentrica, atrophy, and consumption, and by a large proportion of those attributed to cerebral diseases and convulsions, is greatest among those aged one year and under, and is indicative of the procreation of a very numerous feble progeny. This conclusion will hold good, even after allowing for the operation of various conditions unfavourable to infant existence, such as too early marriages and neglect and ignorance of mothers, many of whom are occupied in work away from home and leave their infants in the hands of unfit persons, and often deprived of their natural food, the breast milk."

Dr. Arlidge proceeds to adduce much evidence of the injurious influence of the conditions of employment in the earthenware manufacture (the staple industry of the district) upon the workmen and workwomen —the parents of this "feeble progeny," and upon the children—future parents—who are so employed. The conditions he remarks upon are all still in operation in Hanley, although, it may reasonably be concluded, in a diminished degree. Especially, more attention is paid to the salubrity of the workshops, and the proportion of women and children employed is stated to be considerably less.

There are still other conditions which powerfully influence the vitality of the youthful population and its capacity to resist disease; conditions that come more closely than the others within the controlling power of the local Health Authority. I refer to the sanitary condition of the town, and especially of the habitations of the poor, and to this subject I would now beg to direct attention.

### III.—*Other Sanitary Circumstances of Hanley.*

Hanley stands on an area roughly triangular in shape and about 1,790 acres in extent. At the apex, on the south, it adjoins the town of Stoke-on-Trent; at the base, to the north, is the parish of Burslem; and on the sides (south-east and south-west respectively), it is bounded by the River Trent and the Southhay Brook. The Mersey and Cauldon Canal forms an inner half circle along the line of the streams above mentioned. The canal level is 432 feet above Ordnance datum, and from this contour line the land rises towards the north-east, until, at Hall Fields, an elevation of 643 feet above datum is reached. Upon the intervening slopes the greater part of the town is situated.

The atmosphere of the place is habitually murky. On every side there are large works—pit ovens, collieries, iron works, &c., and the Authority take no effective measures to control the emission of the densest fumes.

The subsoil is chiefly clay or marl, overlying to a varying depth coal and ironstone. Many rows of houses are built on artificial ground,

composed chiefly of "shaff" or potters' refuse, but with an admixture often of road scrapings and refuse containing much organic matter. The use of such deposit in filling-in natural depressions and excavations made for the purpose of obtaining brick earth, is still going on.

The older parts of the town are closely built, and the yard space of much of the cottage property is close and confined. The dwellings are, as a rule, small, and rooms inadequately ventilated. Dampness of walls is a not uncommon cause of complaint in the older property; some of the houses are ill-lighted, dilapidated, and dirty, and the surface about dwellings is often dilapidated and ill-drained. There are a number of houses that, from defects such as these, should be dealt with as unfit for habitation. The sub-letting of rooms in these small cottages is occasionally practised; but it is said that overcrowding, such as the Authority treats as a legal offence, is not often discovered.

The town is sewered throughout, and the sewers are apparently in good working order, well ventilated and flushed. The sewage is dealt with at the outfall works by a combined process of precipitation and application to land. At the Shelton Iron Works, however, a part of the sewage is from time to time intercepted as it flows down a culverted water channel, and is stored in open tanks for boiler purposes. The practice is one that gives rise to occasional complaint.

Private drainage has received much attention of late years, but considerable improvement is still required. Means of ventilation are generally inadequate or altogether wanting; direct connexions between the interior of houses and the public sewers, especially by cellar gullies, still exist in many cases, and privy vaults are stated to be occasionally connected by an overflow pipe with the sewers.

Until 1873 privy vaults or tanks were in general use in Hanley, but since then a number of pail-closets, and still more recently a number of Fowler's closets, or cottage-hopper closets, have been introduced. Of the vaults, however, there still exist a large number, and they are the source of much nuisance. They are often situated in the confined yards close by the dwellings; they are very foul, and there is leakage from them no doubt into the soil, as there obviously is sometimes over the yard surfaces; occasionally the contents can only be removed by conveyance through the dwelling. The new closets (Fowler's) are unprovided with water for flushing purposes, and nuisance occasionally arises from this cause.

The emptying of privies and removal of house refuse is undertaken by the Authority, but is done at too infrequent intervals. Pails are emptied nominally once a fortnight, but even this too extended interval is commonly exceeded. Ashes, &c., are often allowed to accumulate to an excessive amount.

The water supply is from the Wall Grange Reservoir of the North Staffordshire Water Company; the service is nominally a constant one, but appears to be very frequently intermitted for one purpose or another.

The common lodging-houses of the town are insufficiently regulated. The ventilation of the rooms is greatly neglected, and one I found overcrowded. Privy and lavatory accommodation also are insufficiently provided for.

The Authority have, in conjunction with the neighbouring Authorities of Stoke (urban and rural) and Fenton, provided a hospital for the treatment of infectious disease. Hitherto, however, it has been the custom to make a charge, at a somewhat high rate, upon the friends of patients received there. Already much discontent has been caused by this practice, and it is no doubt one that must greatly check the

growth of that popular favour with which such an institution should be regarded.

The ordinary sanitary administration of Hanley appears to have fallen off in efficiency of late years, partly, as seems to be admitted, owing to the increasing age and infirmity of the Chief Inspector of Nuisances. A sub-committee appointed by the Sanitary Authority to make personal inspection of the town after the late outburst of measles, expressed to me their surprise at the prevalence of ordinary filth nuisances, and at the unsatisfactory condition of much of the house accommodation. I met the Sanitary Committee twice during the progress of my inquiry, and on the second occasion related to them the results of my inspection of the sanitary condition of the town. At this meeting it was resolved to recommend the appointment of a duly qualified officer as Chief Inspector of Nuisances. I strongly urged upon the Committee the desirability of placing the work of this officer under the general supervision and direction of the Medical Officer of Health.

# No. I.

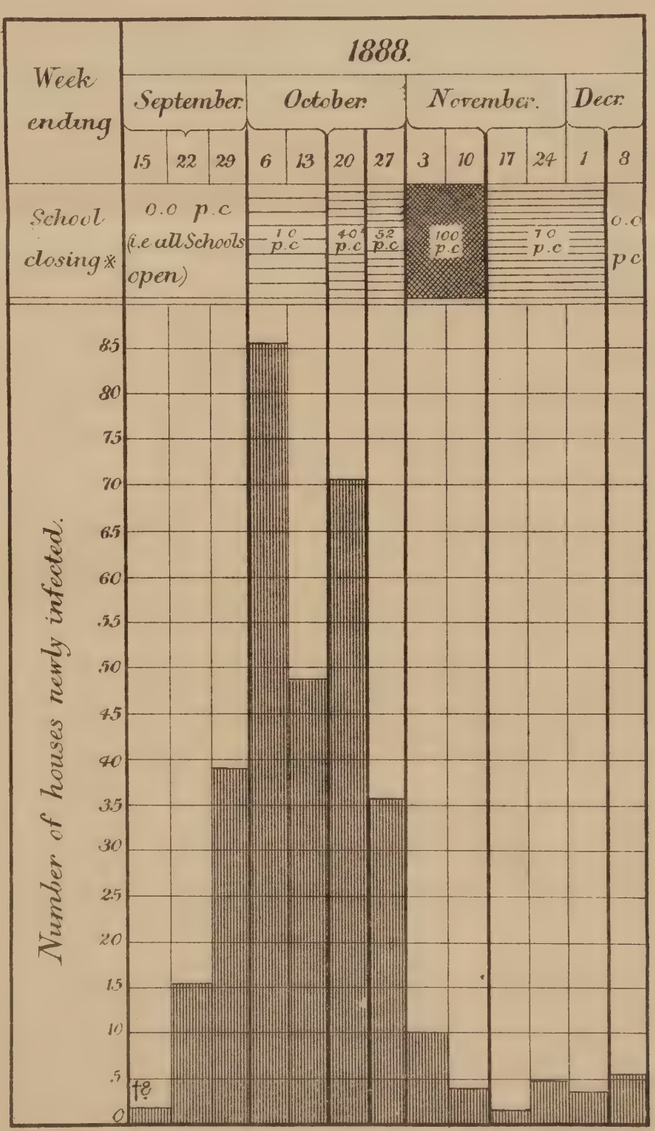
## SHELTON & CAULDON ROAD SCHOOL DISTRICTS.

### SCHOOLS..

CANNON ST. BOARD SCHOOL.
Boys average attendce 345.
Girls " " 225.
Infants " " 190.

WHARF LANE BOARD SCHOOL.
Girls average attendce 180.
Infants " " 180.

SHELTON CHURCH SCHOOL.
Boys average attendce 250.
Girls " " 170.
Infants " " 94.




*i.e. closure of schools to an extent representing x per cent of the average total school attendances of the district.

The above diagram (In which in recording dates of house infection, allowance has been made for the period of incubation) may be read as follows; rapid rise of infection then rapid abatement following partial school closure; rise again and rapid, permanent fall following more complete closure of schools. (The figures in the earlier weeks of the epidemic cannot be regarded as complete.)

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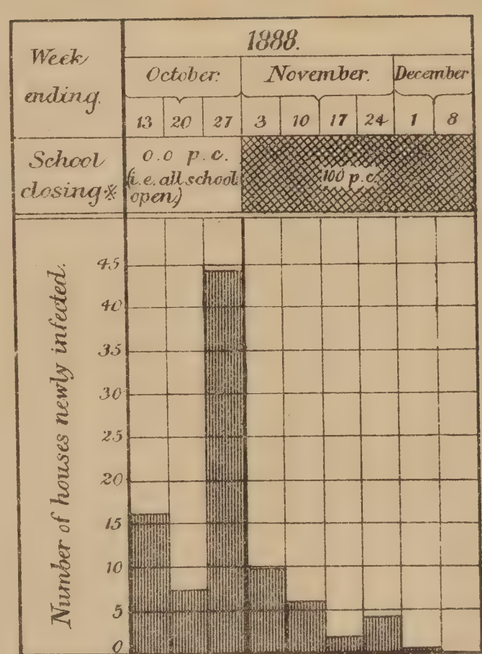
# No. II.

## EASTWOOD SCHOOL DISTRICT.

### SCHOOL.

### EASTWOOD BOARD.

*Boys (average attendance)* ... 197.
*Girls* ... 188.
*Infants* ... 224.




x i.e. closure of schools to an extent representing x per cent of the average total school attendances of the district.

*Rapid and permanent abatement of infection coincident with total and continuous school closure.*

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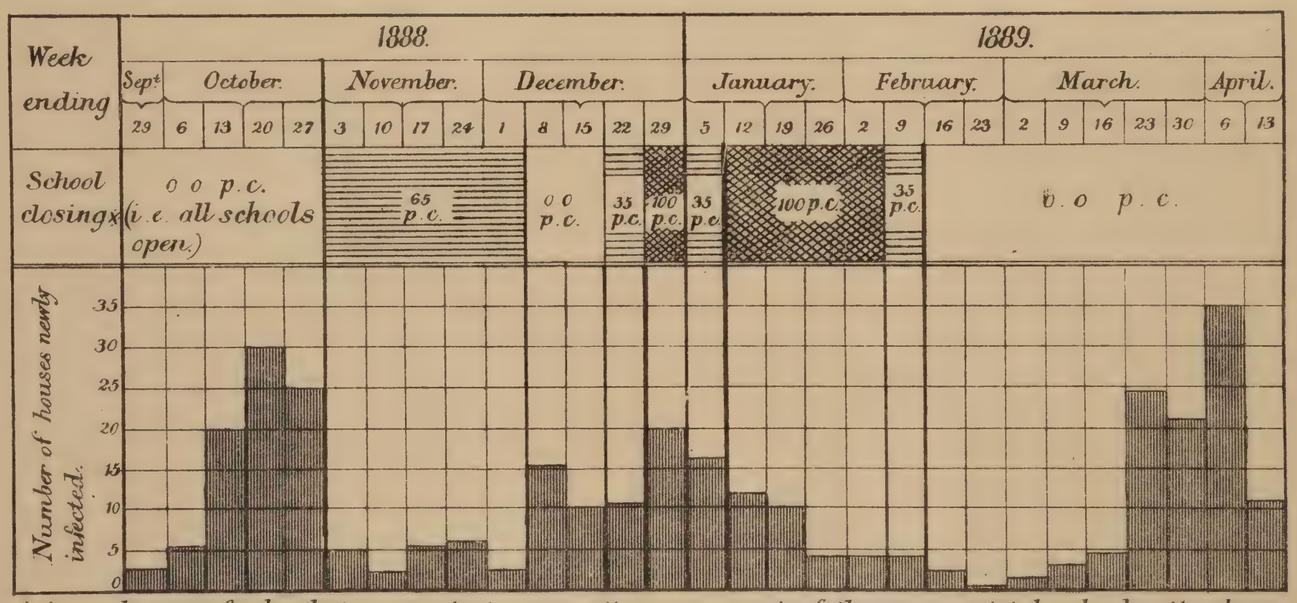
# No. III.

## YORK STREET; SCHOOL DISTRICT.

### SCHOOLS.

| YORK ST.; BOARD SCHOOLS. | | CATHOLIC. | |
|---|---|---|---|
| ---"--- Boys, average attend.ce | 245. | Boys, average attend.ce | 150. |
| ---"--- Girls | 230. | Girls, ---"---"--- | 105. |
| ---"--- Infants | 310. | Infants, ---"---"--- | 153. |




* i.e. closure of schools to an extent representing x per cent of the average total school attendances of the district.

*Rapid decline of infection coincident with closure of York St. Schools; subsequent moderate rise when Schools re-opened. Later, continued but gradually diminishing prevalence for seven weeks in spite of more or less complete closure of schools; quiescence of infection for eight weeks after renewal of school duties, then renewed outburst.*

Judd & Co Ltd Lith. 73 & 75. Farringdon Rd & Doctors' Commons 1216 6.90

# No. IV.

## NORTHWOOD SCHOOL DISTRICT.

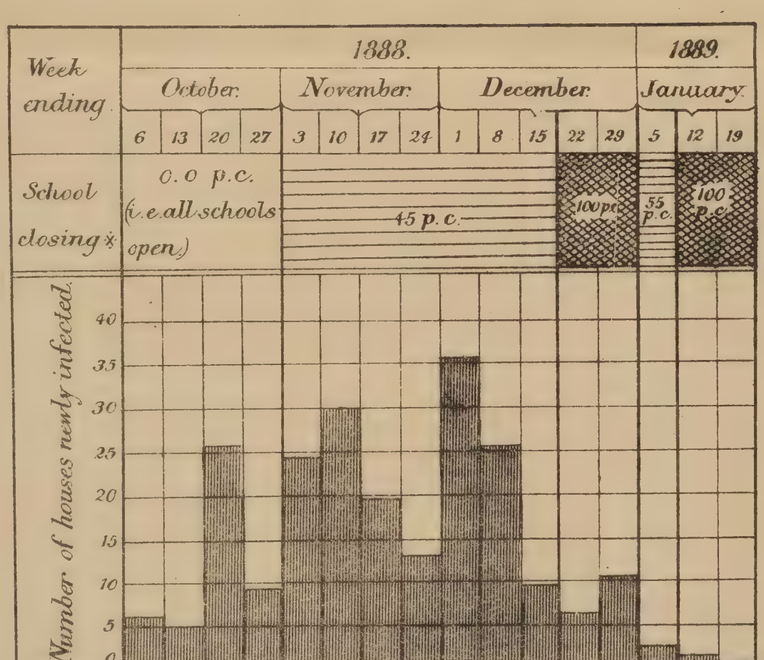
### SCHOOLS.

**BROOM ST. BOARD SCHOOL.**

Boys, average attendance .. 240
Girls, " " .. 240
Infants, " " .. 270

**NORTHWOOD NATIONAL SCHOOL.**

Boys, average attendance, .. 230
Girls, " " .. 220
Infants, " " .. 250
Mixed, " " .. 170




*i.e. closure of schools to an extent representing x per cent of the average total school attendances of the district.

Abatement of infection in week immediately preceding partial school closure, then increase of it and fluctuating amount until the rapid fall immediately preceding total closure of schools.

Judd & Co Lith. 73 & 75 Farringdon Rd & Doctors Commons. 1216. 8. 90.

# No. V.

## Central School District.

### Schools.

**St. Johns Church School.**

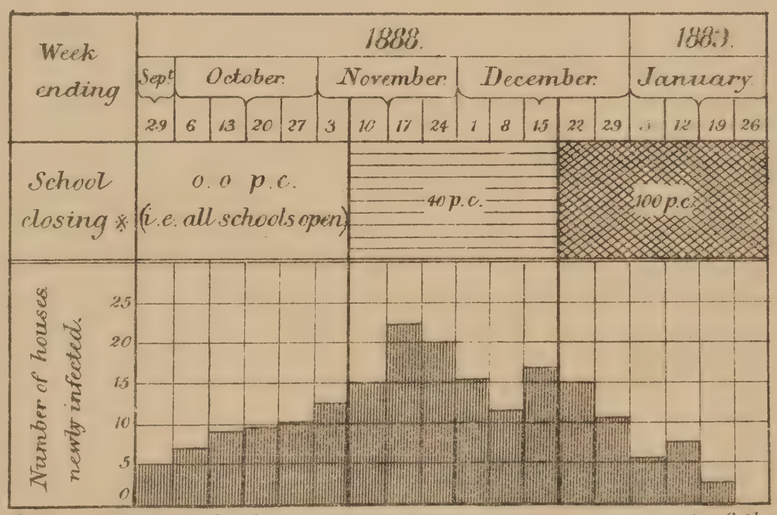
Boys, average attendance 320.
Girls " " 230.
Infants " " 180.

**Wellington School.**

Boys, average attendance 135.
Girls " " 145.
Infants " " 130.

**Wesleyan School.**

Boys, average attendance 300.
Girls " " 230.
Infants " " 200.




* i.e. closure of schools to an extent representing x per cent of the average total school attendances of the district.

Continued gradual increase of infection for two weeks after partial school closure; then gradual abatement, except for the one week preceding total school closure.

Judd & Co Ltd Lith 73 & 75 Farringdon Rd & Doctors Commons 12/5. 6.90

## No. 14.

## Report on the Sanitary Condition and Administration of the Rochester Urban Sanitary District ; by Mr. John Spear.

*Topography, Site, &c.*—The Urban Sanitary District of Rochester covers an area of 2,906 acres, and contains a population estimated now at 23,000, being an increase of 1,693 over the enumeration of 1881. It is situated on either bank of the Medway 10 miles above the junction of that river with the Thames, but not far above where the river may be said to become an estuary of the sea. On the west bank, partly on a tongue of land formed by a bend of the river, stands the old Cathedral city; Strood is on the other bank immediately opposite, and the two outlying villages of Borstal and Frinsbury are situated, the one on the "Rochester side," a mile and a half from the city, on well-elevated sloping ground, and the other at about three-quarters of a mile above Strood. On the Rochester or western side of the river the population is estimated at 15,000 ; on the Strood side, 8,000.*

On the east, that is, toward the estuary, the city adjoins the town of Chatham, and the urban district of Gillingham is situated still a little further below. On other sides Rochester is surrounded by rural areas.

Geologically the district stands upon the Chalk, but a number of houses near the river banks, and especially on the Strood side, are upon alluvial soil, or at Strood, upon "made" or artificial ground. Here the sub-soil water stands habitually some 8 feet from the surface. From these low-lying localities the Chalk hills rise, and it is upon their slopes that the main part of the district is situated.

Until 1884 the low-lying parts of Strood, comprising a considerable proportion of the inhabited part of that division, were much liable to flooding from the river, and in that year the Sanitary Authority, aided by the Bridge Wardens, constructed embankments along the riverside and throughout the ramifications of a small creek, and thus prevented the overflowing. At present, it is said, only the cellars of individual houses exceptionally situated are liable to flooding, and cases of this kind are found on both sides of the river.

*Sewerage and Drainage.*—No regular sewerage exists in the district. Brick or earthenware-pipe highway drains have been constructed in the various parts, and in the low-lying districts overflow pipes from cesspools and privy-pits have been allowed to discharge into these channels; in addition to a few closets and slop-water drains which communicate directly with them. On the river banks and in the small creeks of the riverside I saw certain outlets of the channels spoken of ; the liquid discharged bore all the appearances of ordinary crude sewage, and the mud around was deeply discoloured by sewage matter.

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* As regards population, these are the estimates of the Medical Officer of Health. Those given me by the Clerk and by the Surveyor are considerably higher.

But for this partial exception sewage and slop-water are universally disposed of through the agency of cesspools and privy vaults, and their uncontrolled leakage. The excavations vary from 6 to 10 up to 20 feet in depth; and, made to penetrate the Chalk, are constructed in such a way that soakage from them may be facilitated. They are, indeed, regarded as failing in their purpose if emptying is often required, and this is the reason why in the low-lying alluvial districts overflows have come to be generally provided. Elsewhere it has often happened that when a cesspool has filled, the sinking of a supplementary one, or the use for this purpose of some disused well (regardless perhaps of the fact that other neighbouring wells are not disused), has been preferred to the removal of the old accumulation. The soil on which the town lies has come, in short, to be honeycombed with cesspools and privy-pits; and the foundations of the very houses themselves must often be saturated with the resulting filth. Even in houses now being erected cesspools are sunk within a few feet of the house-walls.

Although the back yards of much of the cottage property of the district are very close and confined, this does not prevent the accumulation of enormous quantities of sewage beneath their surface. Many of the cottages, having no back windows or through communication, are dependent for ventilation from one quarter solely; and it might be thought that the air of this quarter—a space often much enclosed—would be protected with special care from avoidable sources of pollution. On the contrary, the space is generally chosen for the excavation of cesspools and privy vaults; and effluvia from the accumulated filth are constantly poured into the air the purity of which is of such vital importance. I will give a few instances that illustrate the surroundings of much of the cottage property, as well as the action taken by the Authority towards improvement:—

*House in Pump Lane.*—Small, much confined yard; surface dilapidated Deep privy vault sunk against wall of house. Vault emptied about once in two years, and matter then conveyed through the passage (bricked) of the house. Slop-water drain, used by other property also, passes under the same passage, and is said to have been frequently stopped. Stench from the privy-pit much complained of in the dwelling. In January of this year a case of typhoid fever occurred in this house; the drain gully, previously dilapidated, was then repaired, and a 3-inch ventilating shaft from beneath the privy-seat was erected.

*Houses in Baker Street.*—Of better class than that above, and inhabited by well-to-do artizans. Three invaded by typhoid fever in 1888–89; two in 1887; some diphtheria also. Situation well elevated; houses built about 14 years, but street still unmade. No backway to premises, and refuse matter has to be removed through houses. Slop-water conveyed to cesspools in small gardens; privy vaults close to the back of the houses, and privies just beneath side bedroom window. In one case vault not emptied for six years. Stench generally complained of; one tenant saying that the side bedroom above spoken of is uninhabitable from this cause. (The owners, I was informed, have had notice to remove the privies further from the houses.)

*Houses in Morden Street.*—Of same class as the last spoken of. One invaded by typhoid fever in 1888, one in 1887. Cesspool privies just outside kitchen door. "Smell in summer and before rain unbearable." Some of the old wells converted into supplementary cesspools; others

still supplying water for drinking and every household purpose, although said to be full of animalculæ in the summer.

*Pelican Yard, Strood.*—Houses of three stories, but very tiny rooms. Yard space at back a mere passage enclosed by high walls. Privy-pits sunk here against the house-walls; an overflow from the slop-water cesspool passes, it is said, beneath one house, and in that (where children are now suffering from scarlet fever) "fearful smells" are complained of.

*Bull's Square.*—Arrangements there somewhat similar. Drain beneath house, coming from privies, likewise complained of.

*Medway Cottages.*—Direct communication between the kitchens and the overflow pipe (which forms a sort of elongated cesspool) from the privies. Stench in the houses said to be "cruel."

*Taylor's Lane.*—Enclosed back premises; wash-houses within few feet, in one case within three feet, of back doors, and doors immediately opposite. Privy-pits (not emptied for 12 months) within the wash-houses. Ashes and house refuse deposited on unpaved surface in front of the houses. Stench from the privies in the wash-houses pervades the dwellings.

*Thompson's Buildings, City.*—Tiny houses of three stories, no back ventilation. In front, a passage 10 feet wide enclosed by high walls except at the entrance. At the end of this passage large privy pits and two cesspools. In wet weather liquid can be heard overflowing from one to the other and stench abominable. Overflow said to connect one cesspool with a sewer.

*Almond Place, High Street.*—Some of the houses here have out-door closets connected directly with the sewer (highway drain), one at least without the intervention of any pan or other trap. Others have privies, with vaults beneath, built against the kitchen walls. In the latter case the stench is said to be unbearable in the summer, and in two houses ill-health of the inmates was attributed to this cause.

*Ironmonger Lane and Garden Row* form, with several little branch rows, an area, some 50 yards deep, behind the High Street. It is confined and crowded, and abounds in dwellings that, from structural condition and the nature of surroundings, are unfit for habitation. Many of these dwellings have space only at one side, this space being largely occupied by privy-pits having untrapped overflows to the common sewer, by cesspools, &c.; and many that would otherwise be more open are surrounded and hemmed in by these avoidable sources of atmospheric pollution. Several of the inhabitants complain of injury to health from their surroundings, and the place is said to have been often inspected by the sanitary officials with a view to some improvement. So far as I could learn, however, only one alteration had been effected. In one small and much enclosed space a privy-pit had been removed and watercloset with cesspool substituted. The new cesspool (10 feet deep) was sunk within some 4 feet of the main wall of the dwelling-house; and it so happens that on another side of this same house, within about 9 feet of the door, and in a narrow passage, a large foul privy pit, built right against the kitchen wall of a second house, is still left.

Such is the condition of a large proportion of the older cottage property in the town; and that of the newer property, as regards this matter of excrement disposal, is scarcely more satisfactory. At the village of Borstal, where several rows of dwellings have been erected within the last few years, large cesspools and privy vaults, generally unventilated and always leaky, are sunk in the Chalk often close by the foundations of the houses. I saw houses being built, with excavations of this kind within some 12 feet of the house-walls In this village of

Borstal there have been recurring outbreaks of typhoid fever during the last four years; during the last two there have been at least seven family invasions; an epidemic of scarlatina occurred in the autumn of 1888, and there have been besides several cases of "diphtheritic sore throat." The village is situated on a steep hillside overlooking the Medway; the houses are, for the most part, new and airy, and the water supply is from the public source. I could find no explanation for the undue prevalence of typhoid fever, but that of the exceedingly unsatisfactory arrangements for sewage disposal; and certain of the cases of sore throat also had occurred in houses where the invasion of cesspool and drain-air was much complained of.

Many villa residences have been built in different parts of the district of late years, and for these also cesspools afford the only means of sewage disposal. In these cases the distance of the cesspools from the houses is somewhat greater, and more attention is paid to the ventilation of the drains. That a cesspool, however, should be water-tight is never required.

The byelaws of the Authority date back to 1876, or before the model byelaws of the Board were issued. The materials to be used in the construction of drains, cesspools, and the like, the means of ventilation, the situation of cesspools and closets, &c., are to be "suitable," but definite regulations in respect of these important matters being wanting, the result is as described.

*Removal of Refuse.*—Until June 1888, the emptying of privies and cesspools was left to owners or occupiers. It is said that the supervision exercised by the sanitary officers was sufficient to prevent the actual overflowing on to the surface of sewage matter; but in several cases, as stated, the digging of supplementary cesspools, or the use for this purpose of some disused well, was resorted to with a view of obviating the need for frequency of removal. In September 1887, the Board issued a compulsory Order under section 42 of the Public Health Act, 1875, requiring the Local Authority themselves to undertake or contract for the cleansing of cesspools and privies, and by the end of the following June the Authority had, by entering into contracts, completed their arrangements for compliance with this Order. It cannot be doubted that the change will serve an economical purpose, as the cost to the private owner of emptying a cesspool was excessive; it may be expected too that the temptation to dig supplementary cesspools for the same property will, in large measure, be removed, and that the final disposition of the long stored-up filth will be effected with less difficulty and danger. Further than this no advantage can be looked for; enormous masses of filth will still be stored just beneath the surface in the immediate vicinity of dwellings; the foundations of the houses will continue to receive the soakage of sewage; the ground air which largely enters into the composition of the air of dwellings built on the Chalk, will still be impregnated with sewage effluvia; and at recurring intervals, which will be the more frequent according to the frequency of the scavenging, a dangerous and offensive disturbance of filth about the doors and windows of dwellings, at times involving the carrying of such filth through those dwellings, will have to be endured.

As to this last difficulty, however, there is evidently no more disposition on the part either of the Authority or the contractors, than there was before on the part of owners, to empty these receptacles until their emptying is imperatively called for by threatened overflow. Already, on

different occasions, when complaint has been made and the emptying demanded, this has been refused because the cesspools or privy-pits, as the case may be, were "not sufficiently full." From June 26th, 1888, to March 12th, 1889, 306 cesspools or privy-pits are reported to have been emptied by the public scavenger; and the amount of matter so removed appears to have averaged some six tons from each of the several premises, and to have ranged from about two to 18 tons. The figures sufficiently indicate the enormous extent of these accumulations about dwellings.

The only real remedy for the state of things disclosed must, in fact, be looked for in another direction, namely, in the proper sewering of the district and the abandonment of the cesspool system. The necessity of provision for sewerage has from time to time been pressed upon the attention of the Authority by the Board, and in July 1887 the Authority, in response to the Board's representations, endeavoured to open negotiations with the local authorities of Chatham and Gillingham—districts just below Rochester—with a view to the consideration of a joint sewerage scheme. The replies received to these overtures were not favourable, and thereupon the matter fell into abeyance. It is difficult to find sufficient reason for this paralysing effect of declined co-operation. Very probably the three urban districts on this portion of the Medway will ultimately find it advantageous to combine in the provision of outfall sewerage works; but, meanwhile, no sufficient reasons have been adduced why Rochester should delay the execution of its own proper plans. Delay is unquestionably injurious to the health and prosperity of the city.

The removal of ashes and house refuse has been undertaken by the Authority since 1885, and is carried out with fair regularity at fortnightly intervals. Fixed covered receptacles are now generally provided for the deposit of this matter during the intervals of removal, but loose heaps are still occasionally observed on unpaved surfaces.

*Roads, Surface Cleanliness.*—Considerable attention has been paid to the improvement of the main roads of the city, but many of the cross streets and back lanes and alleys are unmade or dilapidated. A considerable amount of "private improvement work," under section 150 of the Public Health Act, is required.

*Water Supply.*—This district is supplied from two public sources. On the Rochester side of the river the mains of the Brompton, Chatham, and Rochester Company are available; on the Strood side, waterworks (purchased of the Strood Company in 1881) are in the hands of the Sanitary Authority. Both supplies are obtained from wells and adits sunk in the Chalk, in situations outside town limits. The water is reported to be wholesome and plentiful; each service is now on the constant system, and adequate pressure is maintained.

In one important respect the house services need alteration. In very many cases at Strood, and in a few in Rochester, I found waterclosets supplied direct from the mains; *i.e.*, without the intervention of any cistern or tank. The danger of insuction of air, and even of solid matter, into the water pipes from closet pans, during any temporary discontinuance of water pressure, is well known to attend this objectionable arrangement.

A number of houses in the district are still dependent upon local sources of water supply. It would appear that on the Rochester side about 125 wells are still in use, and about 10 in Strood. Since 1885,

53 wells have been closed by the Authority, in most cases after chemical analysis has shown the water to be dangerously polluted. Those that remain are sunk in the Chalk, and having regard to the universality of leaky cesspools and privy-pits, it may be doubted whether the wholesomeness of the water that any of them afford (although chemical analysis may have afforded only negative results) can be relied upon.

*House Accommodation.*—From what has already been said it will be clear that much additional attention is required to the cottage property of the district. Many of the cottages are exceedingly small and confined and ill-ventilated; and many in the older parts of the town are dilapidated, damp, and dirty; some few are overcrowded. In certain areas the provisions of the Artizans and Labourers Dwellings Acts should be applied; and in many individual cases application should be made to the Justices to close houses pending such structural improvement as will render them fit for habitation. It is said that of late years one or two of the worst courts have been dismantled owing to the extension of business premises or the like, but very little, if any, action in this direction appears to have been taken by the Authority.

*Provision against Infection.*—In conjunction with the Chatham Urban Sanitary Authority an isolation hospital, used also by the Rochester Port Sanitary Authority, was provided towards the close of 1883. It is situated about a mile and a half from the centre of the city, and consists of two ward pavilions, with means in each for the separation of the sexes. The accommodation it affords, for some 32 patients in all, must be regarded as somewhat meagre for the population it is intended to serve, but the Authority are alive to the possible necessity of temporary extension. It has evidently done much good service, and the inhabitants of the city are said now to accept eagerly the advantages it offers. In his annual report for 1885 the Medical Officer of Health states that 60 cases were removed to this hospital during the year from the Rochester district alone—38 cases of scarlatina, 9 of diphtheria, 9 of enteric fever, and 4 of small-pox—and that after the removal of the initial sufferer no spread of the disease occurred in any case. In 1888 and the first two months of 1889, 77 patients from this district were thus isolated.

There is no organised system of notification of infectious disease in the district, and it is believed that many cases escape the attention of the sanitary officers. Where discovered, in addition to the removal of the sufferers as often as possible to the hospital, disinfectants are supplied gratuitously, and occasionally houses are disinfected by the sanitary officials. A hot-air disinfecting chamber (Ransom's) is provided on the hospital premises.

The number of small seafaring craft entering the Port of Rochester exposes the town no doubt to some danger from the importation of contagious disease. The waters at the mouth of the Medway, and in the Thames below, are within the jurisdiction of the Port of London, and infected vessels from abroad entering the port would be liable to detention there. The town council act as Port Sanitary Authority for Rochester, and the Medical Officer of Health for the city holds the same office for the port. Two "conservancy" officers are retained as inspectors of nuisances, and they, it is said, exercise supervision for the purpose of the discovery of any infectious disease on ship-board. Barges are registered and inspected.

*Administration.*—The Medical Officer of Health, Dr. Sladen Knight, is not appointed under the Board's Order, and copies of his reports are

not forwarded. He receives a salary of 50*l.* per annum. Various improvements have evidently been forwarded by him. The embankment of the river to prevent flooding at Strood, the periodical removal of house refuse, the provision of a constant in place of an intermittent water service at Strood, the gratuitous treatment of patients at the fever hospital, are amongst the measures advocated by him in his reports and since adopted by the Sanitary Authority. No formal representations have yet been made to the Authority under the Artizans and Labourers Dwellings Acts, nor any of importance as to houses unfit for habitation. In the all-important matter of disposal of excrement there may have been some want of insistence in specific advice; nevertheless, I cull the following from his reports :—

In 1879 certain cases of typhoid fever are attributed to defective privy accommodation, and "several cases of illness of a non-infectious character "at Herbert's Cottages, Strood, are caused by the bad smells arising from "defective privy arrangements." In 1880 two cases of typhoid fever in John Street are reported as "probably due to the saturation of the soil from "cesspools," and in another report of the same year the necessity of improved drainage is referred to. In 1882 "many cases of typhoid fever" are reported, and "the chief element of danger and the grand source of "the outbreak has arisen from a soil saturated from overflowing cess-"pools owing to excessive rainfall, and until the cesspool system is "replaced by efficient drainage this will be always liable to recur." In the first half of the following year enteric fever is again reported as "prevalent to a considerable extent in the Medway Division, although "only three deaths have occurred." In 1887, "I look forward to the "period when through a well-devised system of drainage the receptacles "for filth now abounding in our midst, sources of many ailments with "which the population is afflicted, may be known only as evils of the "past; and that cases of typhoid fever, due in great measure to the pollu-"tion of the air and the water by this accumulation of filth, may become "rarer than they have hitherto been, if not altogether disappear; and I "beg earnestly to commend to your consideration the desirability of "carrying out these works from which so great benefits may be confidently "expected."

There are two inspectors of nuisances. One, who is in feeble health, receives a salary of 52*l.* per annum. The other was, I am told, mainly appointed to superintend the scavenging operations, and certainly devotes the greater part of his attention to this work. He is an active officer, and in receipt of a salary of 78*l.* per annum.

*Vital Statistics.*—The collection of reliable mortality statistics is a matter of more than common difficulty in Rochester. Not only are the registration districts not conterminous with sanitary areas, but there are within the city certain small public and charitable institutions receiving inmates both from Rochester and from extra urban localities. The union workhouse for the larger (Rochester) division is, moreover, outside the district; and then, again, there is within it the convict prison at Borstal (which accounts for some 700 of the population), as well as vessels in the port, each and all of which contain individuals amongst whom the death-rate, compared with the general population, is naturally low. The Medical Officer of Health usually calculates the death-rate from all causes, first from the number registered as having occurred in the district, and then from this total number minus all those that, whether belonging to Rochester or not, have occurred in "public institutions" (as the term is defined by the Registrar-General). It will be seen that this latter plan excludes many deaths amongst persons belonging to Rochester; and that the other, while it includes certain

deaths that more properly belong to the Chatham bills of mortality, takes no account of deaths that occur in the workhouse belonging to the largest division of Rochester, no account of cases that may be removed to London hospitals, nor of the presence (in the prison and on ship-board) of a considerable "picked" population.

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[*Two tables were here annexed. They were based on the very imperfect data herein described, and are not reproduced.—G. B.*]

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No. 15.



Extracts from Dr. Blaxall's Report on the Steamship "Neva," in quarantine at the Motherbank, June 1889, on account of Yellow Fever.

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I learned upon inquiry that the "Neva" arrived at Santos (23° S. and 47° W.) on May 7th, and went alongside the wharf on the 13th, where she remained till the date of sailing. Yellow fever had been exceedingly prevalent and fatal at Santos some month or two prior to this date, but at the time of the "Neva's" visit the disease was said to have greatly diminished. The "Neva" sailed from Santos on May 19th, called at Rio on the 21st, Bahia 25th, Pernambuco 27th, Lisbon June 9th, Vigo 10th, and arrived at Southampton on the 13th. She carried a crew of 95 persons, and had about 294 passengers on board; of these she landed 240 at Lisbon. During her stay at Santos there was no special sickness on board, but on May 24th (*i.e.* five days after leaving that port) Bullock, the "barman," was attacked with yellow fever, and died on the 27th. Woods, "bedroom steward," was attacked on May 25th, and died on the 31st. Manning, who was put on to do waiter's duty, was attacked on June 6th, and died on the 13th, the day of arrival at Southampton. Andrews, another of the waiters, was taken ill on June 9th with what the surgeon called Brazilian fever, and died on the 15th, *i.e.* two days after arrival at the Motherbank. Judging from the nature of the antecedent cases, in all probability this man's attack was yellow fever.

Upon the arrival of the "Neva" at Southampton on the morning of June 13th the Customs officer, accompanied by the Quarantine Medical Officer, went alongside. Learning that three deaths had occurred from yellow fever during the homeward voyage (one taking place just before arrival at Southampton, and the body still on board), and that another man was ill on board with what was called Brazilian fever, they ordered the ship to proceed to sea for the purpose of burying the dead body, and afterwards to go to the Motherbank in quarantine. Meanwhile, the matter was reported to the Lords of Her Majesty's Most Honourable Privy Council, who directed the detention of the vessel in quarantine, together with the passengers and crew, until released by their Lordships.* On the 14th June the infected man was removed to the "Menelaus" in charge of the ship's medical officer and two attendants; and the crew and passengers were taken to the "Edgar." Disinfection of the "Neva" with nitrous fumes was then carried out. The infected man died on the morning of the 15th instant, *i.e.* six days after attack, and was buried the same evening in deep water on quarantine ground. The surgeon and attendants were kept on board the "Menelaus" and the passengers on board the "Edgar," but the crew were allowed to return to the "Neva" for the sake of the safety of the ship, in the event of any accident occurring such as breaking away from her moorings.

I accompanied the Quarantine Officer to the ships on several occasions and observed that quarantine was strictly maintained. The Admiralty sent a vessel and crew to row guard during the night in order to prevent intercommunication with those in quarantine. Special precautions were

* A copy of the order was attached to Dr. Blaxall's Report.

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On Yellow Fever on S.S. "Neva"; by Dr. Blaxall.

observed to prevent personal contact with those on board when taking letters, provisions, &c., to the "Menelaus" and "Edgar," and all letters and other articles passed from the ships were fumigated before despatch. The Royal Mail Steamship Company sent a surgeon to take charge of the passengers on board the "Edgar" as the "Neva's" surgeon was on board the "Menelaus." Each day the reports declared no sickness to be present on board any of the vessels, and on Tuesday, the 18th instant, the Quarantine Officer received instructions from the Lords of the Privy Council that the "Neva" and the passengers on board the "Edgar" could be released from quarantine at 9 a.m. on Wednesday, the 19th June, provided all on board were well, but the persons (surgeon and two attendants) on board the "Menelaus" were, however, to be detained in quarantine till Friday, the 21st. Accordingly on Wednesday, the 19th June, the passengers and "Neva" were released with great rejoicing, cheering, guns firing, and the like.

On a visit to the "Neva" the following particulars were gathered respecting the accommodation of the crew, ventilation and other conditions.

The waiters sleep in the starboard fore peak which is the foremost part of the ship on the lower deck. There are 22 wooden bunks arranged three deep on the ship's side for their accommodation. The provision for ventilation consists of a shaft going to the upper deck, and two scuttles in the side of the ship which can be carried open in fine weather.

No record was made of the temperature of the atmosphere during the stay of the "Neva" at Santos, nor for the first eight days after leaving that port; but from the 27th May (date of leaving Pernambuco, and three and two days respectively after occurrence of the first and second case of yellow fever) the subjoined temperatures were noted. Those taken after the date of the arrival of the "Neva" at Ryde were supplied to me by the quarantine officer:—

| Date. | ° Fahr. | Date. | ° Fahr. | Date. | ° Fahr. |
|---|---|---|---|---|---|
| | | | | [Ryde.] | |
| May 27th - | 81 | June 6th - | 70 | June 12th - | 59 |
| „ 28th - | 82 | „ 7th - | 67 | „ 13th - | 61 |
| „ 29th - | 82·5 | „ 8th - | 75 | „ 14th - | 61 |
| „ 30th - | 88·5 | „ 9th - | 74 | „ 15th - | 61 |
| „ 31st - | 79·5 | „ 10th - | 60 | „ 16th - | 62 |
| June 1st - | 76 | „ 11th - | 58 | „ 17th - | 62 |
| „ 2nd - | 74·8 | „ 12th - | Not given | „ 18th - | 64 |
| „ 3rd - | 72·5 | „ 13th - | „ „ | | |
| „ 4th - | 71 | | | | |
| „ 5th - | 69·8 | | | | |

The captain informed me that the men were not allowed on shore during the vessel's stay at Santos, and he could not tell how they contracted the disease. He added that the passengers were examined as to their health on embarkation, and no symptoms indicative of yellow fever presented themselves; though not unlikely some of their luggage might have come from infected dwellings.

In the absence of passengers the waiters sleep in the cabins. The two men first attacked occupied one and the same cabin at Santos situated on the off side of the ship. These men were attacked within a day of each other, thus pointing to simultaneous exposure to infection, although the crew are said not to have been allowed on shore. On May 24th, the date of the first attack, the "Neva" was in the Tropics,

where the temperature of the external air would be over 80°, and up to the 9th June, the date of the last attack, the temperature daily with two exceptions (June 5th and 7th) reached 70° and upwards. It then fell to 60° on the 10th, and 58° on the 11th, and from that date to the 18th instant varied from 59° to 64°.

It is noteworthy that out of some 390 persons on board the disease was confined to four men engaged as saloon waiters. These men were much thrown together, sleeping in the same close compartment, where at night the temperature would be much higher than that recorded on deck, and thus favourable to the spread of the disease. Moreover the last man attacked slept in the bunk immediately under that occupied by the first sufferer, and in which he remained during the first day or two of his illness, before it was recognized as yellow fever. Thus the man last attacked was peculiarly exposed to the risk of infection, if the opinion be correct that the infection of yellow fever hangs about wood with remarkable tenacity.

On the appearance of the disease there was no place ready for the reception of the infectious cases, and one of the ship's officers was cleared out of a deck cabin for the isolation of the infected man. The subsequent cases were removed to lower deck cabins in the fore peak, the waiters being taken away from their usual sleeping quarters.

It will be gathered from the foregoing that the disease was first contracted by a waiter, and it was confined to that class who were living under conditions favourable to its spread. The disease was evidently of a virulent type for all four persons attacked died. The behaviour of the disease goes to confirm the opinion that it requires a temperature of 70° and upwards for its existence. At my interview with the captain I suggested that the company should provide a suitable place on board their ships for the ready isolation of cases of infectious disease, and that the wood fittings of the fore peak and cabins used by the infected men on board the "Neva" should be burnt lest they should give rise to recrudescence of the disease on the return of the ship to hot climates.

*Observations on the quarantine imposed upon the "Neva" and her passengers.*—The detention enforced by quarantine necessarily exposes owners of vessels, owners of cargoes, &c., &c., to very heavy losses, and passengers to considerable and irksome inconvenience. The history of the outbreak on board the "Neva" goes to show that medical inspection with powers to deal with the requirements of individual cases, similar to the powers granted by the Cholera Order, might with advantage, as a safeguard to public health, be substituted for quarantine in regard to yellow fever.

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The hospital ships at the Motherbank would form valuable adjuncts to the Port Sanitary Administration of the authorities exercising jurisdiction over the waters of the Solent. They would be available for the purpose of preventing the introduction of infectious diseases generally into their respective districts.

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*Postscript.*—I afterwards learned of five attacks of fever on board the "Neva" (two of them fatal), antecedent to the cases that form the subject of the present report. They occurred during March 1889.

No information of any value was obtainable about these cases or the circumstances of the ship at the time.

# APPENDIX B.

App. B. No. 1.

On the Etiology of Diphtheria; by Dr. Klein.

## No. 1.

### Further Report on the Etiology of Diphtheria; by E. Klein, M.D., F.R.S.

In a previous Report I showed that a definite infectious disease could be produced on the cornea and conjunctiva of cats, by inoculation into these tissues of particles of diphtheritic membrane derived from acute cases of human diphtheria. The disease thus set up in the cat was found to be a severe conjunctivitis with formation of an ulcer or ulcers on the cornea, commencing as early as 48 hours after the inoculation, and gradually increasing in severity till the end of the second or the beginning of the third week. Also I showed that the muco-purulent discharge from, as well as the opaque tissues bordering on, the ulcer of the cornea would, when transferred to the scraped cornea and conjunctiva of fresh cats, set up in them the same disease. Thus proof was furnished that the induced disease in the cat is of an infectious nature.

Investigation in 1888–89.

Further, I showed that, from the opaque cornea of the cat infected directly with human diphtheritic membrane I could isolate a minute bacillus, which, except in the matter of size, corresponded to bacilli to be observed in large numbers in the membrane of human diphtheria; bacilli which in morphological and many cultural characters could only with difficulty be distinguished from the Klebs-Löffler bacillus described by other observers as present in diphtheritic membranes. Also I referred to another species of bacillus as occurring in diphtheritic membrane stating that I regarded it as being morphologically and regards cultural characters identical with the Klebs-Löffler bacillus; noting further that with cultures of this species (the seeming Klebs-Löffler bacillus) I was not able to produce any positive results in the cat, whereas inoculation of cats with cultures of the particular small bacillus obtained by me from the cat's cornea yielded positive and severe results identical with those obtained by inoculation of the diphtheritic membrane itself. In addition I pointed out that whereas this smaller pathogenic bacillus would grow well on gelatine at and even below 20° C., the other larger and non-pathogenic species isolated by me would not grow at this temperature; and I intimated that while *not* considering this larger bacillus as different from the Klebs-Löffler bacillus, I was disposed to regard the other and smaller bacillus as a distinct species.

During another year I have made further and extensive studies, not only of the bacilli of human diphtheria membranes, and of the experimental results obtainable with these on animals, but also of a disease occurring naturally in cats, and as well artificially producible in them by inoculation of a particular diphtheria microbe. As a result I am, I think, able to give now a ocmplete and satisfactory account on many points concerning the etiology of diphtheria.

Direction of further work, 1889–90.

## I.—The Bacillus diphtheriæ.

By help of Mr. Sweeting (until recently Medical Officer at the Fulham Fever Hospital), I have been enabled to obtain from time to time pieces of diphtheritic membranes removed from the fauces of children affected with acute typical diphtheria. Such membranes I have examined and tested in various ways:—(A.) by microscopic examination as dried and stained cover-glass specimens: (B.) by establishing from fresh membrane, cultures on or in one and another nutrient medium; (C.) by cutting, after hardening in Müller's fluid, the membrane in fine sections and staining these in suitable dyes; and (D.) by inoculation experiments.

### (A.) *Microscopic Examination of Diphtheritic Membranes as Cover-glass Specimens.*

The membrane was always prepared thus:—A particle is cut out from the fresh membrane,* washed well in sterile salt solution, by dropping it into 10 CC. of boiled salt solution contained in a test tube and then shaking it well for a few minutes. The salt solution is next poured off, new sterile salt solution is passed in, and the particle shaken again. By these measures most of the microbes superficially adhering to or embedded in the membrane are easily removed. [The superficial microbes referred to (most of them cocci of one kind or another), which are occasionally present in large masses, are evidently accidental contaminating organisms which have settled and grown on the membrane before it was removed from the diphtheria patient. Similar microbes are abundantly present in the healthy person on the surface of the tongue and in the fluids of the mouth and pharynx.]

Having by these measures thoroughly cleansed the superficial part of the particular sample of diphtheritic membrane, this is rubbed well over the surface of cover glasses so as to spread thereon a thin film of diphtheria material. This film is then dried in the usual manner, stained and mounted. For staining, a 2 per cent. watery solution of rubin is used, and with great success. In this solution the cover-glass specimens are thoroughly well stained if allowed to remain there over night at the temperature of the room; but if placed in the incubator at 36–37° C. they are sufficiently stained in as short a time as half to one hour. After staining, the specimens are well washed in water and placed in methyl-blue aniline water for a few (2 to 5) minutes; then they are again well washed, dried, and afterwards mounted. In specimens thus treated the cell nuclei and the bacteria appear of deep purple-blue colour, while fibres, cell substances, and other intercellular substances are stained a pale pink. In such specimens we notice, it is true, here and there microbes which are cocci, or perhaps slender bacilli, but in a very great majority are the particular organisms which I regard as the diphtheria bacillus. In some fields of the microscope we observe innumerable examples, so that the sample looks like a pure cultivation of the bacilli in question. In Figures 1, 2, and 3 (Plate I.) I have given representations of such a "field." Here were noticed first of all the cylindrical forms, shorter or longer, straight or slightly curved, and characterised by a minute knob-like enlargement at one or both ends. Then were noticed (very numerously represented and forming smaller or larger clumps) cylindrical forms in each of which was a distinct terminal dot deeply stained. These forms, which when crowded together look at first sight not unlike streptococci, are when carefully examined seen to possess a faintly blue-stained cylindrical

Diphtheria bacilli;

* Generally not more than ½–1 hour intervened between the removal of the membrane from the fauces and its preparation in the laboratory.

portion, at each end of which is a deeply stained largish dot (some of them possess more than two such granules) of purple or pink colour, and show therefore a segregation of their protoplasm. The granules in question are either spherical or distinctly rod-shaped, and the terminal element is often cylindrical and possessed of a swelling. In addition were found numerous clumps of the cylindrical bacilli adhering to tissue cells or completely occupying their interior. Also there were conical forms occurring either singly or as dumb-bells joined at their bases; these forms were found scattered amongst the rest or amongst the clumps. All these microbes belong to two species,—the one the true diphtheria bacillus and the other the organism which in my previous report I identified with the Klebs-Löffler bacillus. But to which of these species a given sample belongs cannot always be determined by mere examination of cover-glass specimens, since the resemblance of the one to the other in the matter of size, shape, and general aspect is a very close resemblance. Culture on gelatine and experiment on animals are trustworthy tests by which they are to be distinguished, as will be presently set forth in detail. Including the cases reported on in my previous report, I have now in all examined 22 separate samples of diphtheritic membranes. In some, bacilli resembling in morphological respects what I now regard as true diphtheria bacilli were very numerously present,—so numerously occasionally that they were almost as if in pure culture; in others they were mixed with a considerable number of cocci, and of fine long bacilli. But in all cases in which membrane taken from the fauces of an acute diphtheria case was subjected, after the lapse of a short interval only, to thorough washing as above, cover-glass specimens always contained these diphtheria bacilli in very great numbers, either densely scattered amongst the elements (cells, nuclei, fibres, or débris) of the membrane, or present as clumps adhering to or embedded within the tissue elements. The observations of Klebs, Löffler, Kolisko and Paltauf, Roux and Yersin, Zarniko, and Escherich as to the constant and copious occurrence of these morphologically well-characterised bacilli is therefore a fact easily ascertainable. That in addition other organisms,—as for instance, staphylococci, streptococci, fine bacilli, short thick bacilli,—do occur in diphtheritic membrane, has been noticed by all observers; but there can be no question that most of these occur in appreciable numbers only in the superficial layers: so that I have, by well washing a particle of fresh diphtheritic membrane, in several instances succeeded in almost entirely getting rid of them, with the result that the diphtheria bacilli were almost the only ones left. The statement of Prudden, who maintains that streptococci (which he considers as the diphtheria microbe) are *constantly* present in the diphtheritic membranes, can only refer (if at all indeed it be correct) to the most superficial layer of the membrane, the layer in contact with the fluid of the mouth and pharynx. It certainly cannot refer to the deeper parts of the membrane, since in several instances of typical membranes streptococci were missed from the deeper parts, the diphtheria bacilli being almost alone present there and in large numbers. As I have pointed out in my previous report, many forms of the bacilli in question showing the segregation of the protoplasm, resemble streptococci to a certain extent; but examination with the oil immersion lens soon teaches us that they are really bacilli. I must also repeat that the assumption by some observers (Flügge, Baumgarten, Löffler, and others) that these granular appearances indicate involution forms cannot be accepted as correct, since such forms are very abundant; in fact both in cover-glass specimens and in sections most of the bacilli are granular; indeed in most of the clumps occurring in the tissue of the diphtheria membrane the bacilli are almost all of this kind. The like must also be affirmed

of the forms which show a terminal knob-like swelling either at one or both ends; they are in some places too abundant at an early stage of the diphtheritic membrane to be really involution forms, and as I shall presently show, both forms (the one with segregated protoplasm as well as that with the enlarged end) are always present in the cultures, however recent these may be. In reference to these matters I would invite attention of the reader to the illustrations, Figures 4 to 8, which are reproduced from photographs, in which the morphology of these bacilli in the diphtheritic membrane were accurately and distinctly exhibited.

(B.) *Cultures of the Diphtheritic Membranes.*

Differentiation of the bacilli.

by culture,

A particle of a fresh diphtheritic membrane having been treated in the way above described, viz., by repeated washings in several successive samples of sterile salt solution, and the particle having been well shaken in the last of the series, cultivations are started on the surface of nutrient Agar mixture [by inoculating this medium contained in a test tube with a droplet taken out from the salt mixture by means of a platinum wire or platinum hook]. The Agar mixture may be used as a plate cultivation; or, better still, a droplet from the salt solution may be transferred by means of the platinum hook to the surface of the Agar set slanting in a test tube, and well rubbed over it. In the same way the slanting surface of nutrient gelatine is inoculated by rubbing over it a droplet transferred with the platinum hook from the salt mixture. The Agar tubes thus inoculated are transferred to the incubator and kept at 36–37° C.; the gelatine tubes are either used for making plate cultivations (*i.e.*, melted and poured out into sterile glass capsules covered with sterile cover), or they are placed in the incubator at 19–20° C.

By procedure of this sort I have in several cases obtained at once *pure* cultivations of a particular diphtheria bacillus in the Agar tubes and as well in the gelatine tubes. I show in Plates IX. and X. two sets of tubes of such pure cultures of this bacillus obtained directly from the diphtheritic membrane. In the Agar tubes, however, I obtained often colonies of two kinds of bacilli. These two kinds appear, as regards character, shape, aspect, mode, and rapidity of growth of the colonies, almost identical. But on making further subcultures from each on gelatine they are easily distingnished, for the one kind absolutely refuses to grow on gelatine at 19–20° C., whereas the other grows thereon very well. The bacillus thus obtained which *does not grow* on gelatine at ordinary temperature, I have found *in* 12 *only* out of a total of 22 diphtheria membranes examined. This organism grows rapidly on Agar forming round white patches, thick in the centre, thin at the margin. After a few days the centre, yellowish in reflected light and dark brown in transmitted light, is prominent and convex. In stained cover-glass preparations it shows all those forms mentioned as charateristic of the Klebs-Löffler bacillus. It does not form any appreciable growth on potato at 36–37° C. The other bacillus, that growing indifferently on gelatine and on Agar, and which I identify as the true diphtheriæ bacillus, was found by me in *every one* of the 22 samples of diphtheria membranes. More in detail the behaviour on gelatine of *this* the true bacillus dipththeriæ is as follows:—

As already mentioned, a droplet of the diphtheria membrane and salt mixture having been rubbed over the slanting surface of gelatine, the latter is placed in the incubator at 19–20° C. After 36–48 hours, sometimes a little later, numerous greyish dots become visible as the first indications of the colonies. Under a glass the colonies can be easily recognised as round, minute translucent dots. After 2, 3, or 4 days they can be easily seen with the naked eye as white round convex droplets;

under a glass they now appear convex and dark brown in the centre, thinner and lighter at the margin. After several days to a week or more, they have enlarged to the size of one to several millimetres, are thick, prominent, and yellow in the centre. Under a glass their outline is seen to be slightly irregular, the centre dark brown and prominent; the margin of the growth being thin, plate-like, and light in colour. Where the colonies are closely aggregated they do not reach such a size as where they are isolated (see Figures 24 and 25). Their chief characters then are:—thick prominent centre,—whitish yellowish in reflected light, dark brown in transmitted light,—with an angular thin plate-like marginal part, white in reflected light, brown in transmitted light. Now these colonies are identical with the colonies of that bacillus which I described in my previous report as obtained alike from the cat's cornea purposely infected with diphtheritic membrane and directly from the membrane of human diphtheria itself. It is only in the course of an additional year's work that I have, by the above-described method of washing a particle of fresh diphtheritic membrane in successive samples of sterile salt solution, succeeded in several instances in obtaining at once *pure* cultivations of this species. In my former report I described briefly the characters of the growth in *streak* and in *stab* culture on gelatine, but now, for the sake of completeness, I give further details.

In *streak culture* after about 24 to 48 hours, a greyish translucent band appears; this gradually thickens, and as it does so becomes more and more white in reflected light. At the same time it is clearly observed to be made up of whitish droplets which gradually as they grow merge and become confluent. At the margin of the band, however, the individual droplets are still to be recognised as rounded knobs projecting more or less from the general mass of the band. The band is thick and prominent in the middle parts, flatter in the marginal part. I here draw the attention of the reader to Figures 26 and 32 which sufficiently illustrate these appearances. In *stab culture*, after a few days, a thin grey line indicates the stab; under a glass this is seen to be made up of brownish or brownish-yellow droplets,—minute in the centre, a little larger along the margin of the stab. At the upper end of the stab,—*i.e.*, on the surface of the gelatine,—the growth is more rapid and copious, forming a thick whitish prominent plate with angular thinner margin (see Figure 27). This bacillus, then, is one which, though capable of growing in the depth,—*i.e.*, anærobically,—nevertheless grows better and quicker on the surface,—*i.e.*, is facultative anærobic. These streak or stab cultures in gelatine kept at 19–20° C. show, after one, two, or three weeks, copious growth; as good, for instance, as that of Gaffky's typhoid bacillus; hence we must consider the organism as growing easily and well at this temperature. This is the very important characteristic by which the bacillus which I identify as the true diphtheria bacillus is distinguishable from the Klebs-Löffler bacillus as described by Löffler. Zarniko (Centr. f. Bact.) and Escherich (ibidem) do indeed state that they found that the Klebs-Löffler bacillus grows on the gelatine, though they say it does this very slowly. But my bacillus, as just stated, must be pronounced as showing good growth on gelatine at 19–20° C., as good and copious growth as many microbes about whose power to grow at that temperature there has never been any question, *e.g.*, the typhoid bacillus of Gaffky, the swine erysipelas bacillus, the staphylococcus albus, the streptococcus pyogenes, as well as others.*

* While I was working at this subject, I sent to Professor Löffler of Greifswald several gelatine tubes containing growth of my diphtheria bacillus. These he has compared with his serum cultures of his diphtheria organism and has given the results of the comparison thus made by him, in the Centrallblat. f. Bact. und

As stated already in my previous report there is in alkaline broth at 36–37° C. a difference noticeable between what I took to be the Klebs-Löffler bacillus and the true diphtheria bacillus, the latter growing more rapidly therein and forming as early as after 24–48 hours strong uniform turbidity; a greyish white powdery precipitate afterwards making its appearance in the tubes. On potato my bacillus does not show any appreciable growth. Both species exhibit as fresh specimens, in dried and stained cover-glass preparations, very much the same characters as has been already mentioned; but in the case of my organism the conical forms and the bacilli with segregated protoplasm seem more numerous than in the case of what I regarded as the Klebs-Löffler organism. Cover-glass specimens of cultures of my diphtheria bacillus grown on gelatine, show the conical forms, *i.e.*, pointed at one end thick and club-shaped at the other, in very conspicuous numbers (*See* Figure 7). So that besides the general character and the behaviour of the colonies on gelatine as above stated, these conical forms in cover-glass specimens of gelatine cultures are sufficiently marked to easily distinguish the organism from any other species. At the same time be it noted that these bacilli in gelatine cultures are shorter and thicker than in Agar or broth culture. The difference in the thickness and length of these bacilli under different conditions of culture, as shown by comparing, under an oil immersion lens, specimens from gelatine cultures on the one hand, and from Agar or broth cultures on the other, comes out very markedly in cover-glass specimens stained with rubin, methylen-blue, or gentian violet. And equally conspicuous is a similar difference, particularly as regards thickness, between the organism grown on gelatine and that present in the diphtheria membrane. But that this difference is due not to any involution or degeneration, but entirely to the medium in which the bacillus is grown, is proved—(1) by the fact that at all times from the first appearance of growth on the gelatine,—*i.e.*, within a day or two of starting the culture, the bacilli are distinctly thicker, and most of them are conical; and (2), by the circumstance that if such bacilli be taken from gelatine and planted on Agar or in broth, they at once become somewhat more slender and many of them become longer. So too if retransferred from the broth to gelatine they once more give rise to bacilli which are thicker and on the whole shorter.

The morphological characters of the diphtheria bacilli are shown in Figures 4, 5, 6, 7, and 8. The granular bacilli were very numerously present in the well-stained and well-washed cover-glass specimens, which were from quite recent growths both on Agar and on gelatine. Cylindrical forms with a club-shaped swelling at one or both ends were also easily detected.

Summary of differential characters of diphtheria bacilli.

To sum up:—Two species of bacilli have been obtained by me from diphtheria membranes, which in morphological respects, and in the nature and aspect of their colonies on nutrient Agar mixture (whether in streak or stab culture), are not easily distinguished. Both correspond in these respects to the organism described as the Klebs-Löffler bacillus, but one of these species is not constant, whereas the other is constant in the diphtheritic membrane, and has been obtained therefrom in almost pure culture. The species, which is constant in diphtheria membranes, alone grows well on gelatine at 19–20° C. and differs also from the other

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Parasit. VII. N. 17, p. 528. He therein states that he made sub-cultures on gelatine from my gelatine tubes and from six of his own serum tubes, and found the organisms identical. The organisms from my tubes and the organisms from five out of six of his serum tubes grew well on gelatine at 18–21° C.

as to its growth in broth. It is this bacillus which in last year's report was identified as the true diphtheria bacillus, while the other (which, like Löffler's, did not grow on gelatine) was regarded by me as the Klebs-Löffler bacillus. But now after further study of these organisms, and having regard to the peculiar pathogenic action on animals of my bacillus (in this respect identical with the action observed by Löffler, Roux and Yersin, Zarniko, and Escherich), I am convinced that this bacillus of mine is one and the same with the Klebs-Löffler bacillus of previous experimenters, and that the second bacillus isolated by me (that which did not grow on gelatine) is probably identical with Löffler's pseudo-diphtheria bacillus. It will be remembered that in my previous report I suggested that probably the bacillus with which Roux and Yersin, Zarniko, and Escherich worked was identical with my diphtheria bacillus, notwithstanding that they had failed to discover that the organism which they were regarding as the Klebs-Löffler diphtheria bacillus will grow readily on gelatine at 18–20° C., whereas the pseudo-diphtheria bacillus does not grow at this temperature. I am therefore still of the opinion that Löffler's description of the characters of the Klebs-Löffler bacillus and the description which I accepted last year of the pseudo-diphtheria bacillus, had been confused with each other. And there is another point in which I think Löffler's two species have been confused, and by Löffler himself. It is this:—While the species that *does not grow* on gelatine and which was regarded by me as the pseudo-diphtheria bacillus, dies when its cultures are kept at the ordinary temperature for a few months (and this was stated by Löffler to be the case with his Klebs-Löffler bacillus), the true bacillus diphtheriæ, which *grows readily* on gelatine, does not behave in this manner at all. Thus, I have kept cultures of the true diphtheria bacillus in gelatine tubes for over 18 months and found them at the end of that time living and perfectly active. Further, cultures on Agar of the pseudo-diphtheria bacillus (which I took for the Klebs-Löffler bacillus in my previous report, *i.e.*, the species not growing at all on gelatine at 19–20°), and cultures of the true diphtheria bacillus on Agar and on gelatine, were kept side by side at ordinary temperature for from 4–8 months, to be afterwards tested by setting up fresh subcultures of each. As a result, the newly established subcultures of the former all failed, whereas those of the true diphtheria bacillus all succeeded.

As I shall presently show, and as I have pointed out in my previous report, inoculations of guinea-pigs and cats with what I accept now as the pseudo-diphtheria bacillus do not produce any result, whereas cultures of the true diphtheria bacillus produce on inoculation well-marked and characteristic results. Those obtained by inoculation of this bacillus into the guinea-pig are identical with those produced by Löffler and others with their Klebs-Löffler bacillus, and it is for this reason that, notwithstanding the different behaviour of my diphtheria bacillus, in broth and gelatine, from that recorded by other observers respecting the classical Klebs-Löffler bacillus, I have no doubt now that this latter is identical with my diphtheria bacillus.

There is, however, in addition, a remarkable and interesting cultural peculiarity observed of the true diphtheria bacillus which deserves special consideration. This is its behaviour in milk.

Further and important distinctive characters of the true diphtheria bacillus.

As must be evident from study of the recorded facts respecting the natural history of diphtheria, the contagion of this disease is to be classed with those which, owing to their capability of existing and thriving outside the human body, are termed ectogenic contagia. It is a matter of common belief that a room may retain active the diphtheritic contagion for a very long period; that milk may be not only

the vehicle but even the multiplying ground of the diphtheritic contagium; and that sewer air and sewage may contain and may be the means of distributing this contagium. If, as was at first supposed by Löffler, the Klebs-Löffler bacillus cannot well exist or thrive at temperatures below that of 22° C. (which was the limit given to it by Löffler himself) that bacillus would fail to fulfil the primary conditions required by the above-named generally-accepted belief. Now, as has been said, one of the first points which I ascertained of my diphtheria bacillus was that it can exist well and can thrive well at temperatures below 22° C. Milk, however, which is in this country so well known to be a frequent means of distribution of the contagium of diphtheria, when it is inoculated with the pseudo-Klebs-Löffler bacillus (which does not grow at ordinary temperature) remains, if kept at 20° C., altogether unaltered; that bacillus does not grow in it at all. But if milk after being sterilised be inoculated with my bacillus, *i.e.*, the real Klebs-Löffler bacillus diphtheriæ, and be further kept at ordinary temperature, that is, at a temperature of 18–20° C., the bacillus shows very active growth. Such milk as early as 2–3 days after inoculation shows numerous flakes of casein becoming gradually separated; but at no time during experiment does the milk lose its fluid character. On examining a tube of such milk, after 3–5 days incubation, by the culture test, *i.e.*, by taking out a tiny droplet of this milk by the platinum hook and rubbing it over the slanting surface of nutrient gelatine, there are noticed on this subculture medium after several days at 19–20° C., innumerable colonies of the bacillus; so that the multiplication of this bacillus must have been very considerable in the milk sample, though this had been kept only at 18–20° C. Now, a further curious point is this—that when sterile milk is inoculated with the true diphtheria bacillus and exposed to the higher temperature of 36–37° C. the rate of multiplication of this organism is considerably less than in milk kept at 18–20° C. Many different bacilli inoculated on Agar or in broth and kept at 36–37° C. show of course much more active and rapid growth than if these media be kept at 19–20° C., and the same applies to the true diphtheria bacillus, viz., it grows on Agar or in broth more rapidly at 36–37° C. than at 19–20°. But with this bacillus milk is a complete exception to the rule, for in this medium its growth and multiplication is more active at 18–20° C. than at 36–37° C.; and in conformity with this, the milk inoculated with the true diphtheria bacillus and kept at the higher temperature shows in the same space of time less curdling and the bacilli are less numerous (as shown by the number of colonies coming up in gelatine plates) than does milk kept at 18–20° C. I find in my notes several series of such experiments, and the results are quite uniform. One illustration will suffice:—A series of test tubes containing sterilised milk were inoculated with the diphtheria bacillus. One batch was kept at 36–37° C., the other at 19–20° C. In the second batch distinct casein flakes were noticed as early as after 2–3 days; in the first batch nothing occurred within the same interval; only after lapse of 4–6 days were there obtained in this batch the first signs of casein flakes. Meanwhile a droplet taken at the end of four days from the batch incubated at 19–20° C. yielded innumerable colonies of the bacillus, whereas a droplet taken after the same interval from the batch incubated at 36–37° C. yielded comparatively few colonies.

Bacillus diphtheriæ does not produce spores

Before concluding this section of my report I wish to record the results of experiments in which the true diphtheria bacilli were subjected to a higher degree of heat than 37° C. I have by means of the apparatus described in my previous report studied the degree of tem-

perature that is fatal to this diphtheria bacillus, and I find as a uniform result of many experiments that exposure to 60° C. for five minutes suffices to destroy its vitality. Briefly, the method of experiment was as follows:—Recent cultures, as well as old cultures, on Agar, on gelatine, in broth, and in milk, were used for inoculating sterile broth in test tubes, considerable numbers of the bacilli being introduced in each instance. These broth tubes thus inoculated were then exposed to 60° C. for five minutes and afterwards incubated at 36–37° C. They all remained perfectly sterile, no growth appeared in any of them; whereas control tubes of broth inoculated at the same time and from the same source, but not heated to 60° C., developed in all instances good growth. These results go to confirm very strongly the conclusion, previously arrived at from microscopic observation of these bacilli, as to the absence of anything that can be regarded as spores; for microbes wherein real spores are known to be present have a considerable resisting power towards heat; 60° C. for five minutes certainly has no effect on real spores, whereas many if not all sporeless bacilli and micrococci succumb to such a temperature. The true diphtheria bacillus must therefore be considered as a sporeless bacillus; and the absence of spores in this bacillus agrees with the postulate above stated, namely, that the true diphtheria microbe should be able to thrive at ordinary temperature.

(C.) *Examination of Sections of Diphtheria Membrane.*

Distribution of the bacillus in diphtheria membranes.

A good many sections were made of diphtheria membranes. These were of the characteristic white colour, tenacious, and fibrous. After removal from the fauces of the living patient they were placed into Müller's fluid and kept there for about a week or ten days. Then fine sections, cut in an oblique direction through them, were stained by means of a 2 per cent. watery solution of rubin in which they were left overnight. The sections were next washed in water, and restained by placing them in methyl-blue anilin water for a few minutes. Then they were again washed in water, dehydrated, clarified, and mounted in balsam. The result was highly satisfactory, for in these sections all bacteria had taken a deep blue stain, whereas all of the membrane itself was of a lighter or darker crimson colour. Such sections being oblique all depths are seen. In the superficial layers the matrix is more or less amorphous or homogeneous and reticulated, as is described by all observers. Next comes a stratum in which few nuclei are recognisable, but in the depth of the section numerous nuclei are noticeable in a reticulated matrix which is here looser than in the superficial layers. Both in the superficial and deeper layers there is here and there noticeable the outline of what was unquestionably once a blood vessel, filled with fibrin or remnants of blood. As to micro-organisms in this diphtheria membrane:—in the *superficial layers* are a dense aggregation of smaller and larger loculi, round in outline, completely filled with bacteria. These loculi are seen in one or two layers, and the bacteria filling them are of various kinds. They are cocci, amongst which some thicker or thinner bacillary threads are noticed, and as well even mycelial fungi; but a great many of the loculi, even in the superficial layer, are filled with the particular diphtheria bacilli which I have been describing. These, though they at first sight, owing to their close position, appear as dots like cocci, are, when examined with an oil immersion lens (and by focussing particularly the marginal portion of the loculi) easily made out as bacilli, most of them showing indeed the granular segregation of their protoplasm already referred to. The *mid layers* of a section show also numerous groups and clumps of the bacilli,

but more scattered than in the superficial layer, and connected with one another by strands. Here they are often the predominant microbe or are even entirely unmixed with other sorts; in the preparation of which Figure 9 is an illustration they were present in pure culture. In the *deeper layers* the groups of these diphtheria bacilli are scarcer, but there is no difficulty in finding larger and smaller clumps of them, as are shown in Figure 10. A careful examination of such clumps shows the bacilli all cylindrical, each consisting of a cylindrical pale blue middle portion having at both ends a thick granule stained purple or pink. Under a low power a clump of such bacilli looks as if composed of uniformly granular bacilli, and appears not unlike a group of streptococci; but with high powers their real nature is easily ascertained (Figures 10 and 11). The diphtheria membrane, of which Figures 9, 12, and 13 show sections with their bacilli, was a sample from which by well washing a particle of the membrane *pure* cultures on gelatine of the true diphtheria bacillus were obtained without difficulty. On looking at the illustrations of the sections this will be easily intelligible. In the membrane of another diphtheria case under treatment at the Fulham Fever Hospital about the same time as that supplying the membrane just referred to (this specimen was taken three days later than the other), the same facility was experienced in obtaining at once *pure* cultures of the true bacillus from a particle of the membrane after well washing this in sterile salt solution. Sections made of this membrane showed, however, these bacilli in smaller and scarcer clumps in the deeper parts of the membrane than in the first-mentioned sample, though here also in the deeper parts the diphtheria bacilli alone were to be recognised. But I have seen other cases in which the conditions were not so favourable to easy recognition of the diphtheria bacillus, inasmuch as other bacteria, notably cocci, could be found also in the deeper parts of the membrane. I may mention in this connexion a diphtheria case in which death occurred before the end of the first week of illness. Here the whole pharynx, the mucous membrane lining the back of the larynx and covering the epiglottis, as well as that lining the whole larynx and the first inch or two also of the trachea, were covered by a thin greyish-white diphtheritic membrane. Sections having through these different structures having been stained and examined, it was found that though in some parts the diphtheria bacilli were extremely numerous (as for instance in the larynx and about the epiglottis, where they formed a continuous layer), they were present only in the diphtheritic membrane itself; and even where this was thick, as in the pharynx, they were present chiefly in the superficial layer. In many places there were present in the superficial layer of this membrane other bacteria also, viz., long bacilli, cocci, and even mycelial fungi.

In sections through the uvula, pharynx, and larynx of a child which also died before the end of the first week, and in which these organs were covered with diphtheritic membrane, I can trace large numbers of the diphtheria bacilli into the mucosa next to the diphtheritic membrane itself (Figures 13 and 14); that is to say, into parts of the mucosa in which the distended blood capillaries, filled with blood corpuscles, and the tissue cells are still distinct and not yet merged in the necrotic portion. This layer had in fact the diphtheria bacilli in pure culture. In particular sections through the larynx, I have seen the entire superficial layer of the mucous membrane filled with almost continuous masses of diphtheria bacilli as it were in pure culture; small groups of the organisms extending also into the deeper parts of the mucous membrane.

Thus far, then, my observations are in complete harmony with those of Klebs, Löffler, and others, who found their diphtheria bacilli only in the

diphtheritic membranes themselves, though I more often than they found diphtheria bacilli abundantly present also in the deeper portions of the diphtheritic membrane, and in the inflamed mucous membrane.

D.—*Inoculation Experiments with the Diphtheria Bacillus.*

Diphtheria bacilli inoculated into guinea-pigs:

(*a.*) *On Guinea-pigs.*—Inoculations of guinea-pigs into their subcutaneous tissue with the cultures of the true diphtheria bacillus yielded very characteristic results. For such inoculations, cultures on Agar, in broth, and on gelatine were used. The cultures were original cultures, *i.e.*, made directly from the human diphtheritic membrane, or were at most subcultures only a few removes therefrom. In all instances Agar or broth cultures used for inoculation of guinea-pigs were from one day to a week or two old; gelatine cultures were from several days to several weeks old. [I have, however, satisfied myself that the gelatine cultures are still virulent even if more than a month old, though the same cannot be said of cultures on Agar or in broth kept at 36–37° C. for a similar length of time. As I shall show later, these bacilli lose considerably in virulence if kept on or in those media at such temperatures.] From the surface of an Agar or gelatine culture selected for experiment a particle of the growth is removed with the platinum hook, and introduced into about 10 c.c. of sterile salt solution in a test tube. By shaking this tube up a mixture results which is slightly turbid. In practice I have commonly in my experiments used gelatine cultures, for the reason that with such cultures of some standing (*e.g.*, several weeks old), the result is more certain than with cultures in other media. Broth cultures I have used directly when recent (*i.e.*, 24–72 hours old); they act very virulently, but broth cultures have this disadvantage, namely, that the chemical products elaborated during the growth of the bacilli and distributed in the broth are liable to be introduced in considerable quantity along with the organism of experiment. As Roux and Yersin found, the broth which had served as the culture medium of the bacilli is in itself highly poisonous on account of the presence of these chemical products. In the salt mixture made with a particle of the Agar or gelatine growth no chemical products to speak of are included, since I always carefully singled out a particle of the growth on the surface of these media so as to avoid removal of any portion either of the Agar or of the gelatine itself.

positive results.

When about $\frac{1}{4}$–$\frac{1}{2}$ a c.c. of such a slightly turbid salt mixture as I have described is inoculated into the subcutaneous tissue of the groin of a guinea-pig, a positive result is manifest, as early as after 12 hours. The animals are quiet, and have a tender, soft swelling at the place of inoculation; they do not move readily, and their coats are rough. In 24–30 hours they are moribund; temperature has by this time fallen several degrees centigrade; they cannot move at all, but seem paretic in their hind extremities; their coats are very rough, and their eyes are partially closed. In the groin of the inoculated side there is now a soft swelling of considerable size. Some experimental animals are dead before 24 hours are past, others die in about 30 hours, and others again at the end of the second day or even later. On making a post-mortem examination the following appearances are found:—At and about the seat of inoculation the connective and muscular tissues (of thigh, groin, and abdomen) show œdema and hæmorrhage; in rapid cases this is less copious than in slower cases, and in the latter the connective tissue seems split up into discoloured lamellæ separated by more or less distinct clefts,—the tissue being indeed in an almost gangrenous condition. In still slower cases, such as die after two or three weeks (see (*i.*) on p. 155), there is

found about the seat of inoculation a firm tumour involving the subcutaneous, cutaneous, and muscular tissues of the groin, thigh, and abdomen. On cutting into this tumour, sanguineous fluid oozes out; within the tumour are streaks of hæmorrhage and thick whitish layers, looking remarkably like the human diphtheritic membranes, and being indeed due to necrosis of the tissue. In some cases, however, the œdematous swelling and the hæmorrhage are only slight and limited almost entirely to the lymphatic inguinal glands, these being, however, in every case more or less swollen and deeply congested. As regards the viscera, and speaking generally :—Both *lungs* show general congestion, with here and there a lobule more deeply red, almost purple; the *pleural* and *pericardial* cavities contain sero-sanguineous exudation; the *liver* is in some cases only very slightly congested, in others not at all, or even abnormally pale; the *spleen* is not enlarged, and is not congested. The serous coverings of the *stomach* and *intestines* are congested; the latter are relaxed, and the *peritoneum* is injected, containing sometimes fluid exudation; the *kidneys* are slightly congested; the *suprarenals* are always deeply congested. These appearances coincide, then, perfectly with those described by Löffler and others. In those cases, however, in which the disease takes a more prolonged course, as, for instance, when lasting several weeks, there is found in addition distinct lung disease; particular lobules are in a solid grey state; the pleuræ contain exudation with fibrinous threads; the liver shows a few greyish spots and patches; the kidneys show congestion of the medulla and distinct signs of fatty degeneration of the cortex,—there being present whitish-grey streaks in the cortex, and whitish-grey patches beneath the outer capsule. We shall see further on that this condition of the kidney is characteristic of the disease in the cat, when the malady has lasted in that animal several days.

I proceed now to note the results of some of the experiments on guinea-pigs made with cultures of bacilli from diphtheria membranes :—

(*a.*) Two guinea-pigs inoculated with a *first* subculture on Agar five days old :—

Both very ill, and presenting an obvious tumour *at the seat of* inoculation, after 16 hours. One guinea-pig died in 24, the other in 28 hours.

(*b.*) Two guinea-pigs inoculated with *original* culture on *Agar* three days old :—

Both very ill in 24 hours, and dead in 30 hours.

(*c.*) Two guinea-pigs inoculated with a *first* subculture on *gelatine*, six days old :—

Both very ill in 24 hours; dead before lapse of 36 hours.

(*d.*) Two guinea-pigs inoculated with *original* culture on *Agar*, 12 days old :—

One animal died in eight days; the other survived.

(*e.*) Two guinea-pigs inoculated with a *first* subculture on *Agar*, eight days old :—

Both ill and with obvious tumour in two days; one dead in four days, the other survived.

(*f.*) Two guinea-pigs inoculated with a *first* subculture on *Agar*, two days old :—

Both ill in 24, and dead in 30 hours.

(*g.*) Three guinea-pigs inoculated with a *first* subculture in *broth* two days old :—

All very ill, and with obvious tumour, in 16 hours; two dead in 24, the third in 30 hours.

(*h.*) Two guinea-pigs inoculated with a *first* subculture on *gelatine*, five weeks old:—

Both ill, and with obvious tumour in 48 hours. One died after four, the other after six days; this latter having received a smaller dose than the first.

(*i.*) Two guinea-pigs inoculated with same material on the same day as the (*h*) guinea-pigs above; but one of them receiving only one half the dose of guinea-pig (*h*) No. 2, the other only one-fourth part of such dose:—

Both had slight tumour after 48 hours: the swelling increasing from day to day, and becoming firm. The first animal died after 17 days, the second after 21 days.

(*j.*) Two guinea-pigs inoculated with a *first* subculture on *Agar*, 17 days old:—

Both ill; one died in 24 hours, the other survived.

(*k.*) Two guinea-pigs inoculated with a *first* subculture on *gelatine*, one month old:—

Both were ill within 24 hours, and had large tumour; both dead in 30 hours.

From these experiments we see then that gelatine, Agar, or broth cultures are very virulent while fresh, *i.e.*, two to six days old; and that Agar cultures after eight days or longer, and gelatine cultures after five weeks keeping, are less virulent and cannot be relied on as uniformly infective to guinea-pigs.

From the bodies of the majority of the above guinea-pigs dead after inoculation, cultivations were made:—of the heart's blood, of the congested lung, of the spleen, of the congested kidney, of the congested suprarenals, and of the pleural exudations. But in no case were any organisms obtained,—the culture tubes all remained sterile. The same negative results had been obtained by Löffler, and he therefore expressed the opinion that the disease and death of his experimental animals must have been due to a chemical poison. The general pathology and the absence of the diphtheria bacilli from the blood and viscera do indeed almost exclude any other explanation. Further, the fact that there is always a very marked and characteristic local lesion produced at the seat of inoculation is consistent with manufacture there of a chemical poison, which being absorbed by the system sets up the general disease, followed by death. And this explanation of Löffler suffices also to account for diphtheritic process in the human subject. For as with the experimental guinea-pig so with the diphtheria patient, no diphtheria bacilli are found in the blood or in the viscera; the diphtheria bacilli do not extend further than the diphtheritic membrane. One is at liberty to infer therefore that the diphtheria bacilli produce also in man a chemical poison which being absorbed by his system sets up in him the constitutional disease—diphtheria. Roux and Yersin, moreover, have actually succeeded in separating from their broth cultures a chemical poison, and by injecting this in large doses into guinea-pigs have produced in them illness and death. Roux and Yersin, therefore, agree with Löffler in his interpretation of the modus operandi of the diphtheria bacillus.

The bacilli not recoverable from bodies of experimental guinea-pigs,

In reference to the inferred local manufacture within the animal body of a chemical poison through the life processes of diphtheria bacilli, I have sought to ascertain whether in the guinea-pig these micro-organisms are specially abundant or particularly virulent *at the seat of the experimental inoculation*. Accordingly, as regards the majority of the above guinea-pigs I have made a number of cultures from the

except from site of original inoculation.

enlarged and congested lymph-gland of the inguinal region of the inoculated side, and have generally by the Agar or gelatine method isolated the diphtheria bacillus which had been used for inoculation; in a few instances I did not succeed, but in the majority I obtained colonies. My method of procedure was this:—The inguinal gland was removed with sterile instruments, and a particle of the gland rubbed over the slanting surface of Agar or gelatine. In some tubes I got colonies in such large numbers that it was scarcely possible to count them; in other tubes their number was more limited. Sometimes there were not more than from one to ten colonies (Figures 28, 29, 30, and 31). In aspect, colour, and mode of growth the colonies (and as well subcultures made from them) were the same as those from the material used for the original inoculation; and similarly under the microscope the bacilli of these colonies (and of subcultures from them) presented characters identical with those of the bacilli of the cultures used for the original inoculation. On using such cultures or subcultures obtained from the experimental guinea-pigs for further inoculation of other guinea-pigs (and of cats as will be shown on a further page) their action was found to be very virulent; guinea-pigs inoculated with a gelatine subculture (obtained from the inguinal gland of experimental guinea-pigs) 2 to 14 days old, die in 24 to 36 hours.

There can be no question then that the diphtheria bacilli introduced into the subcutaneous tissue of the inguinal region of experimental guinea-pigs, do grow and multiply there, and produce there, a local definite disease: œdema, hæmorrhage, and necrosis. But this is not the same thing as proving that they produce there in addition a chemical virus, which, being absorbed into the system, makes the animals very ill and ultimately causes their death. For it was possible that in each successful experiment, there had been introduced along with the bacilli enough of the chemical product of those organisms to cause the physiological results observed. In order, therefore, to test the point, I undertook the following experiment:—A slightly turbid salt mixture was made from a gelatine culture, in the manner already mentioned, and from it two control guinea-pigs (*a.* and *b.*) were inoculated in the groin each with $\frac{1}{4}$–$\frac{1}{2}$ c.c. Then the rest of this salt mixture was exposed to 60° C. for 5 minutes, rapidly cooled, and afterwards used for inoculation of gelatine and Agar tubes, and as well for inoculation of two other guinea-pigs (*c.* and *d.*). The Agar tubes were incubated at 36–37° C., the gelatine tubes at 19–20° C. All the tubes remained sterile, and guinea-pigs *c.* and *d.* remained perfectly well; they had no tumor nor illness. But the control guinea-pigs (*a.* and *b.*) soon became very ill; they had large tumours and were dead in 24 hours. Now these *a.* and *b.* guinea-pigs, be it remembered, had been inoculated with a fluid that subsequently, *after sterilization*, proved absolutely harmless to companion guinea-pigs. To *a.* and *b.*, therefore, it was infective solely by reason of the living organic matter which it had contained; and these guinea-pigs on post-mortem presented just the same appearances as all other guinea-pigs in which inoculation had succeeded,—*i.e.*, they harboured the bacilli in their swollen and congested inguinal glands, but no bacilli whatever could be found in their blood or viscera. This experiment goes far, I think, to prove: (*a*) that the animals died from absorption into their systems of a chemical poison; (*b*) that this chemical poison resulted from the life processes within them of the bacilli; and (*c*) that the bacilli when introduced into the groin in a living state, multiply there and produce there the chemical poison in question.

Cats inoculated with the diphtheria bacillus;

(*b.*) *Inoculation of Cats.*—In last year's report I have shown that with diphtheria membrane a definite infectious inflammation of the

conjunctiva and cornea leading to corneal ulcer, can be produced in the cat by rubbing a particle of the diphtheritic membrane over the cornea and conjunctiva from which the surface epithelium has been previously scraped off. Such positive result is visible even in 18 hours; after 24 hours the eye is injected and slightly watery; but after further 24 hours the eye is closed, the conjunctiva congested and swollen, and the cornea shows commencing slight opacity. The disease becomes gradually more intensive and pronounced, and before the end of the week the cornea shows distinct ulcer. The corneal tissue forming the boundary line becomes at the same time loosened and opaque, the conjunctiva much inflamed, œdematous, and at the internal canthus there collects muco-purulent matter, which also as a thin film covers the cornea and conjunctiva. In the severer cases no abatement of the intensity of the process is noticed till the end of the second or beginning of the third week; in milder cases this takes place as early as during the second week or even sooner. That this process is a specific process I have already proved by showing that diphtheritic membrane is alone capable of producing it, and further that if the opaque corneal tissue of the ulcer, or the muco-purulent matter of the inflamed conjunctiva, be transferred to the cornea of another cat, it sets up there the same disease. Also, I have pointed out in my previous report, that the same bacillus which was obtained from the human diphtheritic membrane, was isolated by culture from the tissue of the opaque cornea of the cat that had been inoculated with a particle of the diphtheritic membrane. This bacillus I stated presented the same characters on cultivation (Agar, broth, or gelatine) as the human diphtheria bacillus; but that in microscopic specimens of the corneal tissue it was distinctly smaller than the latter.

Superficially into cornea and conjunctiva.

During the year just passed a number of additional experiments on the cat's *cornea and conjunctiva* have been instituted with cultivations of this diphtheria bacillus, and with results in most cases very striking; in a few instances only the inoculation was followed by very slight re-action, in the majority severe conjunctivitis with ulceration of the cornea was the result. I subjoin a few further instances of successful inoculation of cats:—

1. With this cat's cornea bacillus, carried on in a series of gelatine subcultures during four months, the scraped cornea of a fresh cat was inoculated; the subculture used was nine days old. In the cornea and conjunctiva of this cat the result was positive and very pronounced, there being present, on the ninth day, much congestion and œdema of the conjunctiva, with opacity and slight ulceration of the cornea. By the end of the third week the process had begun to abate, but even after six weeks there was still some opacity of the cornea remaining.

2. From a subculture of the cat's cornea bacillus in broth (to which had been added a small piece of boiled white of egg) kept at 36–37° C. for seven days, the scraped cornea and conjunctiva was inoculated in two cats. On the third day the inflammation of the conjunctiva was pronounced in one of these cats; nothing was visible in the other animal. In the first animal the conjunctivitis and opacity of the cornea was considerable on the seventh day; but no conspicuous ulcer on the cornea was developed. By the 12th day the conjunctivitis had begun to abate, and by the 19th day there was left only slight injection of the conjuctiva with slight opacity of the cornea, and the eye appeared slightly watery.

3. From a culture of human diphtheria bacillus on Agar, nine days old, the cornea and conjunctiva (previously scraped) of two cats were inoculated, by rubbing into the surface of these membranes a particle

of the growth. In both these animals the disease set in with great intensity, the eye being closed as early as after 17 hours and the conjunctiva congested; but while in one of the cats the whole process did not last for more than a week, in the other it led to the formation of a deep crater-like ulcer in the centre of the cornea. On the 14th day both eyes of this cat were closed, copious muco-purulent matter had collected at the inner canthus, and the conjunctiva was much congested and swollen. The cornea of one eye was slightly ulcerated and opaque; the cornea of the other eye showing an ulcer in the centre about $\frac{1}{6}$–$\frac{1}{4}$ inch in diameter, with swelling and opacity of the corneal tissue at the margin of the ulcer. This animal was killed on the 17th day, the disease still progressing. The ulcer of the cornea reached, as examination proved, down to the Descemet membrane. Figure 36 shows the condition of this cornea.

4. From an Agar subculture of human diphtheria bacillus, eight days old, the corneæ and conjunctivæ of other two cats were inoculated. In both animals, after 48 hours, the conjunctiva was found injected, the cornea slightly opaque, and there was much watery secretion. After three days this secretion was slightly purulent, the corneal opacity, the congestion, and the swelling of the conjunctiva had increased, and the disease became daily more intense. On the seventh day the eyes of both animals were closed; on the eighth day ulcers on the cornea were obvious in one animal. One of these cats was killed on the 15th day; in this case one cornea was opaque and slightly ulcerated, the other cornea showed a deep crater-like ulcer with raised opaque margin; conjunctiva much congested, swollen, and coated with purulent matter. The other cat had on this day considerable suppuration from the conjunctiva of both eyes, the cornea being opaque, but not distinctly ulcerated.

5. From a gelatine subculture of human diphtheria bacillus, about four weeks old, the cornea of a cat was inoculated. On the fourth day there was a distinct ulcer on the cornea with great congestion of the conjunctiva and muco-purulent discharge; on the sixth day the ulcer was spreading, the conjunctivitis increasing, and the discharge more copious. The disease increased steadily, until towards middle of the third week, when there occurred perforation of the cornea and the formation of staphyloma (see Figure 37). The margin of the cornea had now become swollen and opaque, the conjunctiva bulbi œdematous and deeply congested. This animal was killed about the end of the third week.

6. While the disease was taking its course in the above case and during the second week of that cat's illness, another and healthy cat ($x$) was placed in the same cage with it. A few days later it was noticed that in this cat ($x$) the conjunctiva of one eye looked much injected, that the cornea showed a central opacity, and that there was copious secretion of tears. After a further interval of a couple of days the above process was more intense, and there was slight superficial ulceration in the centre of the opaque cornea; but in two more days the conjunctivitis was distinctly abating and the superficial roughness and ulceration of the cornea was almost gone, though there was distinct opacity still visible in its centre.

It is evident from this experiment (No. 6) that the conjunctival disease was in this instance casually communicated from cat to cat as it was last year communicated by direct experimental inoculation with the opaque tissue removed from the corneal ulcer of a previously infected animal. During this year's proceedings this experiment of direct transmission has been repeated with like success; thus,—

7. From the ulcerated cornea of No. 1 cat (page 157) on the ninth day of the induced disease, flakes of the opaque corneal tissue were removed and inoculated into the corneæ of two fresh cats. Twenty-four hours later their conjunctivæ were found much congested, and their eyes very watery. Forty-eight hours later the congestion and exudation had become less in one of the animals; but in the other the eye was found closed, the conjunctiva much swollen and congested, and the cornea slightly opaque. While the eye in the first animal became normal again by the fifth day, in the latter the acme of the disease was not reached before the end of the week, by which time the cornea showed distinct opacity, with roughness of surface at the centre; the conjunctiva meanwhile had become much swollen (œdematous) and congested, and there was muco-purulent matter at the inner canthus as well as on the cornea and conjunctiva. So that in this animal at any rate the inoculation with the tissue of an ulcerated cornea produced positive result.

8. A last experiment of this particular series was one in which for inoculation of the cornea and conjunctiva a subculture of the diphtheria bacillus derived from the inguinal gland of an experimental guinea-pig (guinea-pig (*a*), p. 154) was used. From an Agar subculture derived from the guinea-pig in question the scraped cornea and conjunctiva of a cat was inoculated. After 24 hours the eye was partly closed, and there was slight discharge of mucus; after 48 hours the eye was completely closed. On the fifth day the eye was still closed; on opening it the conjunctiva was observed to be much swollen and highly congested; the centre of the cornea was opaque and there was a distinct ulcer thereon. The animal was at the same time quiet and off its feed; it was killed on the seventh day. *Post-mortem.*—The ulcer was found to be crater-like and reached to nearly the Descemet membrane; the conjunctiva was much congested and œdematous, and there was purulent matter at the inner canthus and on the conjunctiva.

Subcutaneously in the groin.

In an additional series of experiments, cultivations of the bacillus diphtheriæ obtained from human diphtheria, and the same organism after it had been passed through the guinea-pig, were both of them used for *subcutaneous inoculation* of cats. The results of such inoculation were likewise very striking. In this series of experiments (except when otherwise stated) a salt mixture made slightly turbid with culture material was used as in the experiments on guinea-pigs already mentioned,—about $\frac{1}{4}$–$\frac{1}{2}$ c.c. being injected into each animal.

1. From a culture on Agar directly derived from a human diphtheria membrane, the culture being nine days old, three cats were inoculated into the subcutaneous tissue of the groin, and on the following day three additional cats were inoculated with the same culture.

All six showed after 24 hours swelling in the groin at the seat of inoculation, and were slightly off their feed. After three days the swelling in the groin was in each case considerable, the animals remaining quiet and off their feed. Two were found dead at the end of five days, two others after 10 days, and the last two after 11 days. The *post-mortem* examinations showed:—extensive hæmorrhage in the subcutaneous and muscular tissues, with œdema in the groin, abdomen, and thigh; the tissue in many places discoloured, appearing as if split up by clefts into lamellæ, and almost gangrenous. The *lungs* and *spleen* were congested; the *liver* slightly congested. Both *kidneys* showed

Condition of kidney,—

enlargement and as well a remarkable change which consisted in almost the entire cortex being grey and fattily degenerated, the medulla appearing by contrast much congested. When examined with a lens the cortex appeared composed of numerous whitish streaks separated by the reddish Malpighian corpuscles; near the capsule the whole tissue was uniformly white. This condition was noticed even in the two animals that died first, *i.e.*, after five days, and it was more pronounced in the other four animals. Under the microscope it was seen that in all the uriniferous tubules,—particularly the convoluted tubules,—the epithelium was swollen and fattily degenerated or broken down into a granular débris. In Figures 38, 40, and 41 the aspect of such a kidney is well shown.

pathognomonic of diphtheria in the cat.

Now it especially deserves notice that this condition of the kidney is extremely characteristic of diphtheria disease in the cat. Not only does it occur uniformly and in a pronounced degree in cats subcutaneously inoculated with diphtheritic membrane, but, as I shall proceed later to show, this same peculiar condition of the kidney occurs also in cats naturally affected with a curious infectious disease, which would appear to stand in intimate relation to human diphtheria. In this connexion I need hardly call the attention of the reader to a fact well known to pathologists, namely, that in the human subject also the cortex of the kidney in diphtheria, which has lasted many days or some weeks, shows similar whiteness due to fatty degeneration.

2. Two cats were inoculated subcutaneously in the groin with a gelatine subculture of the diphtheria bacillus (14 days old) derived from an experimental guinea-pig. Both animals showed after 24 hours swelling at the seat of inoculation, and one of them was found dead before 48 hours were over. The *post-mortem* examination in this case showed the same changes in the groin, abdomen, and thigh as in the cases already recorded: especially great congestion of *lungs*, and as well congestion and hæmorrhage in *uterus*, pelvic connective tissue and *ovaries*. The *kidneys* showed, too, a deeply congested medulla, with pale cortex, in which were conspicuous greyish-white patches of fattily degenerated tissue. These patches were either isolated or, in some places, more or less confluent.

The second animal died in 50 hours with identical post-mortem appearances.

3. From a broth culture (48 hours old) of the bacillus diphtheriæ derived from an experimental guinea-pig, two cats were inoculated in the subcutaneous tissue of the groin. After 24 hours both animals had swelling in the groin, and were very ill and quiet. One animal was found dead in 40 hours, and on post-mortem the changes were found to be the same as in the animals mentioned just above. The second cat of this series was killed, and the same changes were found in the groin and viscera as in its companion, though in the kidney the fatty patches in the cortex were decidedly fewer.

4. Two cats were inoculated from an Agar culture, two weeks old, derived from one of the experimental guinea-pigs. Swelling at the seat of inoculation was noticeable in each case in 24 hours, and the animal was quiet. After 48 hours the swelling in the groin was considerable, and the animals appeared very ill. After seven days the animals were still very quiet and off their feed. They were now killed. At the post-mortem examination changes of the sort already recorded at the seat of inoculation (œdema, hæmorrhagic infiltration of subcutaneous and muscular tissue, with lamellation and gangrenous condition) were found to be more distinct. The *kidneys* of both cats were

enlarged and white, the whole cortex being of a whitish-grey colour due to fatty degeneration, and the medulla deep red.

From these experiments we see, then, that a distict local disease is producible in the cat by inoculation of the diphtheria bacillus,—a disease completely identical with, but more intense than, that produced in the guinea-pig, the gangrenous condition of the subcutaneous and muscular tissue being more pronounced and the extravasation more extensive than in that animal. Further, the same general congestion of the viscera as in the guinea-pig is to be noticed in the cat; and lastly there occurs in the cat a characteristic enlargement and fatty degeneration of the cortex of the kidney, which is the more pronounced the longer the disease has lasted. It is partial as early as after two days, pronounced after five days' illness, and very marked later on.

Summary of results of inoculation of cats.

From the œdematous and hæmorrhagic subcutaneous connective tissue of these cats' groins, cultures were made. As regards some of the animals no diphtheria organisms were obtained; from others, dead after 48 and 50 hours, a few colonies of the microbe were recovered, and these presented exactly the same cultural characters as the diphtheria microbe, though under the microscope they appeared distinctly smaller. This same fact was, it will be remembered, ascertained also with regard to the diphtheria microbe obtained from the ulcerated cornea of the cat in last year's experiments; it was smaller than that derived directly from diphtheria membrane.

Simultaneous inoculation of cornea and groin.

An interesting result is obtained when cats are simultaneously inoculated, superficially in the cornea and subcutaneously in the groin. For this purpose recent subcultures were used, derived from human diphtheria membrane, which had proved on subcutaneous inoculation virulent to guinea-pigs and to cats. With such a culture two cats were simultaneously inoculated, both of them into the cornea and in the subcutaneous tissue of the groin; a third cat was at the same time only subcutaneously inoculated. This animal developed great swelling at the seat of inoculation, grew quiet, and was decidedly ill as early as after 48 hours. It was killed after seven days, and on *post-mortem*, the usual changes at the seat of inoculation were found very pronounced; both kidneys were large and white, the cortex being white and showing fatty degeneration. The other two animals developed the disease on the cornea and conjunctiva, but showed only slight inguinal swelling. When killed after 19 days each exhibited one kidney slightly enlarged, with but slight fatty degeneration of the cortex.

I note in addition some experiments carried out with gelatine culture of the diphtheria bacillus obtained last year from the ulcerated cornea of an experimental cat. The culture used was a subculture six days old, but removed from the original culture by several generations, carried on during four months.

Two kittens and two adult cats were inoculated subcutaneously with this subculture. There was in all four animals a slight soft swelling noticeable in the groin at the end of 24 hours. This swelling increased gradually and became firm after 5–6 days. The animals, though quiet during the first two or three days, became after this all right again; the swelling then decreased gradually, and after a fortnight nothing was left of it. They were killed after six weeks. In one of the kittens no abnormal condition could be found anywhere; no change in the kidneys. But the other kitten showed a few dark red almost black

patches in the spleen, and in both kidneys the cortex showed grey fatty patches.

One of the adult cats showed the kidney change very distinct, the cortex being white, and under the microscope the tubules were in a state of granular or fatty degeneration. The other viscera appeared normal. The second adult cat showed the following appearances :—in both *lungs* there were several lobules in a state of solidification, grey and firm ; in both *kidneys* the medulla much congested ; the cortex of one kidney showed only a few white fatty patches, but in the other the whole cortex was conspicuously white and fatty.

The result of these inoculations, though positive, was nevertheless not so pronounced as in the previously recorded cases, since even after six weeks the morbid changes in three of the animals were not as advanced as those observed after only five days in cats of the earlier experiments. This result may have been due to the age of the culture employed.

## II.—Disease naturally occurring in Cats in association with Human Diphtheria.

Diphtheria naturally occurring in cats.

I come now to a very important point of this inquiry, in that I have to deal with a disease naturally occurring in the cat at times when and in places where diphtheria was found to be affecting the human subject. In illustration I quote from the *British Medical Journal* of May 10th, 1890, the following passages :—"Dr. George Turner has brought "together some instructive examples in a paper published in the "Appendix to the Annual Report of the Medical Officer of the Local "Government Board for 1886. In one instance the disease appears to "have been conveyed from some children to a cat. The children had "been infected while attending the village school ; they lived in an "isolated cottage, and during their illness were confined to the upper "rooms. No food which had been offered to the sick children was "set before the others, the mother habitually gave it to the cat. This "animal subsequently suffered severely, but eventually recovered. Dr. "A. Jacobi has published another example ; five children were ill with "diphtheria in one house ; three kittens who had been playing with "them died from time to time, and *post-mortem* examination showed "diphtheritic membranes in their throats.

"Again, the report made by Dr. Bruce Low in 1888 to the Local "Government Board on an epidemic of diphtheria at Enfield contains "the following significant history :—A little boy had a fatal attack of "diphtheria. On the first day of his illness he vomited, and the cat "licked the vomit on the floor. In a few days (and after the death of "the boy) the cat was noticed to be ill, and her sufferings being so "severe and similar to those of the dead boy, the owner destroyed her. "During the early part of its illness this cat was let out in the back "yard ; a few days later the cat of a neighbour who lived a few doors "off was noticed to be ill. This cat also had been out in the back yard "at night. This second cat recovered, being carefully nursed by four "little girls, all of whom developed diphtheria. There was no other "known source of infection to which these girls had been exposed but "this cat.

"In 1885 Dr. C. J. Renshaw contributed to this Journal a paper in "which he described some cases in which cats, who had swallowed

" portions of recent diphtheritic membrane from human sufferers, con- " tracted a disease, apparently diphtheria, to which they succumbed in " from a week to a fortnight."

As further coincidences of cat disease and human diphtheria I will mention certain instances in which I had the opportunity to examine the cats thus affected. Towards the beginning of 1889 Dr. Arthur Downes, at that time Medical Officer of Health for Chelmsford, informed me that he had on some occasions observed an incidence of diphtheria in the human subject coincident with very obvious malady in cats belonging to the invaded households. Here is a case in point, about which I quote from Dr. Downes's letter :—" Frank A., aged six, " and his sister Catherine, aged five, were attacked by diphtheria " *simultaneously* on January 14th. On the 17th another sister, aged " eight, also was attacked. The house was an isolated farm. The " children's movements were easily traced, but it did not appear that " they had been within range of any known source of infection; they " were educated at home, and though there had been one or two " visitors at the house, these were not known to have been in contact " with any case of diphtheria. Milk-infection was excluded. Shortly " *before* the children sickened, their favourite cat, which they were in " the habit of fondling, fell ill, lost its voice, had a husky cough, " attended by choking, and was observed to make efforts to clear its " throat with its paws. The mother compared its symptoms to those " of her children, and strongly suspected the cat as the source of their " infection. Diphtheria had been prevalent in a village three miles " away, and cats had died there ; but whether of poison or of disease " the evidence did not say. Last year in my Chelmsford district a cat " died with symptoms strongly resembling diphtheria, which commenced " a day or two after she had licked the vomit of a child ill with " diphtheria of bad type."

I have quoted this in extenso from Dr. Downes's letter in order to show that in his view (the view be it observed of an experienced medical officer of health) there existed strong primâ facie evidence of a probable connexion between human diphtheria and a definite disease in cats.

The cat mentioned in the first part of Dr. Downes's letter was sent alive to me on February 20th. By this time the cat had become thin, but otherwise showed no symptoms of illness. The animal was killed. On post-mortem examination the *lungs*, *liver*, and *throat* showed no abnormal appearance; the *spleen*, however, showed several dark red, almost black, patches, while both *kidneys* were large, and their cortex (which was whitish grey) completely fattily degenerated.

Post-mortem appearances.

A second good instance is the following :—

On March 7, 1889, I received a letter from Mr. Shirley Murphy to the following effect: " A family has had two cases of diphtheria " *following* the illness of two cats in the house, one of which died. " The illness of the cats led to swelling of their throats and interfer- " ence with their respiration." Mr. Murphy was kind enough to put me in communication with the veterinary surgeon, Mr. Daniel, of Camden Town, who attended the cats and had made a post-mortem of the one animal that had died. Mr. Daniel informed me that the animals had evidently affection of the throat with difficulty in swallowing, and that he had seen and known of several cases of similar malady amongst cats. He indeed regarded this malady as an infectious disease not uncommon amongst cats in his neighbourhood; in fact he

had just then several bad cases under treatment. Mr. Daniel further told me that the disease commenced with swelling, congestion of the throat, and respiratory difficulties; that in some animals the malady tends to a prolonged pulmonary disease, in the course of which the cats become thin and die. One such cat having died was sent to me by Mr. Daniel. At the post-mortem examination the following changes were found. In both *lungs* there were present several more or less well-defined lobular patches of solid grey hepatisation, some of them isolated, others confluent. The smaller patches were more or less circular, about a quarter of an inch in breadth, the larger about half an inch in diameter. In the right lung the upper lobe was almost completely solid and grey. The *liver* showed on its surface several small black patches, besides a few greyish spots. Both *kidneys* were greatly enlarged and white; the entire cortex was whitish yellow, being made up of whitish-yellow streaks and patches. In microscopic sections the uriniferous tubules of the cortex were all fattily degenerated.

Mr. Daniel also sent me a living cat of the same batch. This cat had been ill for three weeks; its disease had commenced with sneezing and difficulty in swallowing, and as well difficulty of respiration. When I received it, it was thin and had marked paresis of the hind limbs. I kept the animal for five weeks, during which it grew gradually thinner, and the paresis increased to complete paralysis. The animal was then killed, and on post-morten examination the following appearances were noted:—*liver* enlarged, full of black patches of various sizes; both *kidneys* enlarged and white, on section the entire cortex whitish yellow and fattily degenerated.

As a third instance, I refer to a cat sent me by Dr. Thursfield, of Shrewsbury. This cat came also from, and had died in, a house where there was diphtheria. Dr. Thursfield says :—"The cats were taken ill some "days before the children, and when ill were carried about and nursed "by the children. The first child was ill with sore-throat November "26th. The second case, a child in the same house was ill with diph-"theria on November 27th. The first cat, ill November 18th, died "December 1st; second cat, taken ill November 18th, died December "4th; the third cat was taken ill on November 25th, and died December "7th. The symptoms were: wasting, loss of appetite, inability to "swallow, cough, and expectoration." On post-mortem examination of the cat sent to me I found: in both *lungs* patches of lobular grey hepatisation (Fig. 42); some patches isolated, others confluent.* The *liver* was uniformly mottled grey and red, the grey streaks and patches corresponding to fattily degenerated liver tissue around the intralobular vein. Both *kidneys* were enlarged, the enlagement in one being more pronounced than in the other; in the former the whole of the cortex was white from fatty degeneration, in the latter there were only patches of grey fattily degenerated tissue.

Post-mortem appearances of disease naturally occurring in the cat identical with those observed in cats inoculated with diphtheria bacillus.

It would appear, then, that cats are really subject to an infectious disease occurring in association with human diphtheria; that in this naturally-acquired disease of the cat the affections of the lungs, liver, and kidney in prolonged cases are very marked; and that the affection of the kidney is identical with that induced in cats alike by subcutaneous inoculation with diphtheritic membrane and with cultures of the diphtheria bacillus.

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* It is hardly necessary to remind the reader that in human diphtheria also, lasting for several weeks, catarrhal or lobular pneumonia, as well as fatty degeneration of the cortex of the kidney, is an almost constant complication.

In a word, this disease casually occurring in the cat is very similar to the malady artificially producible in that animal by inoculating it with human diphtheria material. Hence arises very strong suggestion that the above infectious disease occurring naturally amongst cats may in its turn be a source of human diphtheria, as indeed would seem to have been the case in one or more of the above-recorded instances of associated cat malady and human diphtheria.

Cultivations were made by me from the diseased lung and diseased kidney of the two cats sent me by Mr. Daniel and from corresponding organs of that sent by Dr. Thursfield. But I have not been able to obtain therefrom any microbes at all comparable to the diphtheria bacillus. In just the same way I failed to obtain by culture the diphtheria bacillus from the diseased lung, liver, and kidney of the cats (and guinea-pigs) which I had infected by subcutaneous injection into them of the cultures of the diphtheria bacillus. And accordingly, it will be remembered, I arrived, with Löffler and others, at the conclusion that the disease and death thus experimentally induced is not due to a real infection, but to a chemical poisoning,—the chemical poison having been produced locally, *i.e.*, at the seat of inoculation. But if this be so, the question may very well be asked,—Where, in the naturally diseased cats, is the seat of production of this chemical poison? Is it produced in the nasal mucous membrane, or in the throat, or in the lungs. I myself suspected the lungs strongly. In these cases there was always early pulmonary trouble, and it is likely enough that the diphtheria bacilli were even then present in the lungs and doing their work there (*i.e.*, producing the chemical poison there), though it is true enough that some weeks later they had disappeared from lungs altogether, so that when such a diseased lung came to be bacteriologically examined, diphtheria bacilli were no more to be found there than in the human fauces after the acute stage of diphtheria has passed off. There is not indeed, as far as I can see, any organ more likely to be the seat of the invasion and multiplication of the diphtheria bacillus in the natural disease of the cat than the lung; the throat, be it remembered, does not in this cat malady show ulceration or membranes, and is not likely therefore to be the seat of the contagium.

To put my surmises to the test in some sort, I instituted the following experiments :—Broth culture of the human diphtheria bacillus that had been growing at 37° C. for seven days was injected directly into the trachea of two cats by means of a Pravaz syringe, each animal receiving one syringe full. The trachea was not previously opened, but the cannula was pushed through the anterior wall between two of the cartilaginous rings, and the fluid then gradually injected into the cavity of the trachea. About five minutes after the injection both animals showed distinct spasm and rigidity in the muscles of the limbs and back ; but these only lasted a few seconds. Next day both cats were found very quiet and ill. One seemed to be dying; it was lying on its side not able to move, and its temperature had sunk to 36° C. In both large râles could be heard at the upper part of the lungs. One of the animals died in 26 hours. On post-mortem examination, the mucous membrane of the *trachea* was found congested; the left *lung* hyperæmic, the right lung one mass of hæmorrhage, the *pleura* costalis along the ribs on the right side appeared one streak of hæmorrhage; there was œdema of the connective tissue in the region of the *thymus* gland; the cervical *lymph glands* were much congested and swollen; the *liver* was congested; both *kidneys* were enlarged, the

medulla deeply congested, but the cortex less so and showing more or less confluent patches of greyish-white tissue. Cover-glass specimens of the lung juice and of the bronchial mucus were made, and herein the presence of the diphtheria bacillus could be definitely demonstrated (Figure 46). They were mostly either contained in the swollen cells or were adherent to their protoplasm. These bacilli were, like those observed in the ulcerated cornea and in the hæmorrhagic subcutaneous tissue of the cats previously mentioned, distinctly smaller than samples obtained directly from diphtheria membranes.

The second cat remained very quiet and off its feed till the sixth day when it was found very ill; it had paralysis of right hind limb and was lying on its side unable to move. It was now killed. On *post-mortem*:—the left *lung* in its upper lobe showed a round consolidated deep red patch about $\frac{1}{2}$ inch in diameter; the upper half of the lower left lobe was entirely and redly hepatised. The *liver* was large, completely and uniformly fattily degenerated. Both *kidneys* were enlarged, the cortex forming a uniform mass of whitish-yellow fattily degenerated tissue (see Figure 40).

Cover-glass specimens made of the hepatised lung showed abundance of diphtheria bacilli either in groups within cells or adhering to them.

Cultivations made of the lung juice of both cats revealed the presence of colonies of the bacillus diphtheriæ besides numerous colonies of staphylococcus aureus liquescens.

A point of especial anatomical importance in connexion with this induced disease in the cat is the following:—Sections made of the hepatised portion of the lung of the second cat showed (in addition to extensive hæmorrhage into the alveolar and infundibular cavities) the bronchi greatly distended, and having their lumen—and as well their mucous membrane as far as their circular muscular coat—occupied by what appeared under the microscope the exact counterpart of a diphtheritic membrane such as is seen in sections through the tonsils, palate, and pharynx of a case of typical human diphtheria. This false membrane of the bronchi of the cat presented just that necrotic reticulated matrix (containing blood and remains of tissue elements) which is characteristic of human diphtheria membranes. And immediately around the muscular coat of such a bronchus there was great congestion of the blood vessels with extravasation of blood into the tissue and accumulation of leucocytes.

In the naturally acquired disease of cat, the lungs probable seat of local diphtheria process.

From these observations it follows, then, that by introduction of the diphtheria bacillus into the lungs of a cat a disease is set up there which is, tissue for tissue, the counterpart of human diphtheria; meanwhile the other anatomical appearances of this induced disease, as regards the liver and kidney, are of the same kind as those observed in the naturally-acquired disease of the cat and in that induced in this animal indifferently by subcutaneous inoculation of a particle of human diphtheria membrane or of artificial cultures of the bacillus diphtheriæ. I am therefore disposed to consider the cat as particularly susceptible to diphtheria, though differing from the human being in this, namely, that the local disease occurs generally in the lungs and not in the fauces. Further, I suspect that contagium of the cat when this animal infects the human subject is derived from her diseased lung, and that the cat herself contracts diphtheria by receiving the contagium into her respiratory organs, as well as (which will presently appear) by way of her alimentary system.

## III.—Milk and Diphtheria.

Milk and diphtheria:

Dissemination of diphtheria by milk is now in this country so generally accepted, and has, moreover, unhappily, been so often demonstrated, that the fact of such dissemination of the disease needs not to be insisted on. Since discovery of this fact, however, ten or a dozen years ago, the means by which milk can acquire ability to convey diphtheria has remained matter of doubt and even of controversy. But as time has gone on it has become more and more evident that satisfactory explanation of milk-diphtheria outbreaks through infection of the milk by some antecedent human case of diphtheria is seldom forthcoming. Among more recent papers on this subject is one* in the 16th Report of the Medical Officer of the Local Government Board respecting a milk-diphtheria outbreak in 1886 at York Town and Camberley, which lends itself conveniently in illustration of the difficulties met with in these cases in accounting for infectiousness of the milk. At York Town and Camberley the ability of the implicated milk to cause diphtheria in the human subject was pronounced, and persistent day by day from the 8th to the 18th October. Nevertheless no human source of infection of the milk could be detected, and the main outcome of inquiry had to be stated in these words:—

infectivity of the milk difficult of explanation.

> "The milk which did the mischief had a like quality of infectiousness
> " on each of four several milk-walks, and has to be regarded as
> " having become infected before leaving the farm where it was
> " produced." * * * "The method of the infection of the
> " milk has not, in the present state of knowledge on this subject,
> " been demonstrable."

This unsatisfactory conclusion was not, however, arrived at without due inquiry as to means whereby the milk might have become infected. After excluding as non-operative at the farm in question, one after another of the commonly-accepted means of milk infection, the report goes on to consider, in provisional explanation of the observed facts, certain hypotheses, each of which regarded the cow herself as concerned in transmission of diphtheria infection, as follows:—

> "The one regarded the cows as agents merely in transmitting,
> " without increasing the amount of it, débris of human diphtheria
> " from water to milk; it did not require that the cows themselves
> " should suffer any illness or inconvenience in the process. The
> " other regarded the cows as principals in the business of milk
> " infection, requiring that they, or some of them, should, after
> " having received (no matter in what way) potential diphtheritic
> " material into their bodies, become more or less ill as a con-
> " sequence, the material of diphtheria multiplying in their bodies
> " and pervading their systems, becoming secreted with their milk,
> " and so being conveyed to persons consuming it.
>
> "In regard of the first hypothesis it was suggested that a diph-
> " theria case occurring about mid-September in a cottage half a
> " mile from the farm had afforded specific infection material which,
> " when cast on to or into the soil of the garden might have found
> " its way by October through many yards of earth into a small
> " stream hard by, which subsequently passed through the meadows

* Report on an Outbreak of Diphtheria at York Town and Camberley in the Farnham Rural Sanitary District; by Mr. W. H. Power.—Report of the Medical Officer for 1886, pages 311–326 [C.—5171.].

" whereon the cows at the farm were pastured. Further, it was " suggested that the cows, by wading in this stream or by drinking " of the water, might have received on or within (according to " circumstance) their bodies the diphtheria material brought down " by the stream. And finally, it had to be suggested that diph- " theria material thus annexed by the cow could either have been " swept in the act of milking from her teats into the milk-pail, or " else being excreted from her system (as matters non-assimilable " by cows are excreted) could have been delivered there unaltered " along with her milk secretion; the animal herself suffering " meanwhile no inconvenience whatever." Perhaps, says the reporter, the chief recommendation of this theory is its novelty.

" According to the second and simpler, perhaps because more " daring, hypothesis, it would have been enough that one or other " of the cows in milk in the early part of October, or a cow or " cows newly coming into use for the dairy at that date, should " have been attacked (say towards the end of September) by some " infectious malady akin to diphtheria; that the material cause of " such malady becoming multiplied in the body of the cow should " have pervaded her system; and that at some stage of her malady " (say in early October) this multiplied infective material should " in due course have found its way into her milk, to be of necessity " distributed to all the dairy's customers. Against this theory is " the fact that seemingly not one of the cows at the farm had " been ill at all. On the 13th of October a veterinary surgeon " certified all the cows as in good health, and on the 21st of the " month a second veterinary authority could not detect any disease " among them; two only of the cows showing at that date the " slightest signs of 'chaps' on their teats. For the hypothesis, on " the other hand, there is little to be said, unless it be allowed to " regard the business of calving and cleansing as perhaps involving " some unnoticed process morbid in its nature; and then one " appearance of parallelism is indeed discernible, namely, that two " cows calving on the 17th and 23rd of September respectively, began " to supply milk for the dairy just about the time that the milk " distributed from it commenced to infect people with diphtheria. " As matter of fact, at the beginning of November one cow at the " farm (not newly calved) which had suffered 'chapped teats' still " had at the site of a 'chap,' a scab or crust, not unlike those " which at a later stage of their malady had been observed to " replace ulcers on the udders of certain Hendon cows."

These facts and considerations acquire now, in view of what we have just learned of the natural history of diphtheria, especial interest and importance. Accordingly I have judged it necessary to forthwith test on milch cows the action of the diphtheria bacillus.

Two milch cows (No. 1 and No. 2), which had calved about 3 or 4 weeks previously, were therefore procured. For a week to ten days antecedent to experiment, they were kept under observation at the Brown Institution, far removed from my laboratory. They were in excellent condition, fed well, gave abundant and good milk, and their udders and teats were perfectly clean and natural.

Experimental inoculation of cows with bacillus diphtheriæ:

On a given date I inoculated both animals, by injecting (subcutaneously) under the skin of the left shoulder of each, one Pravaz syringe of a broth subculture of the bacillus diphtheriæ (derived directly from human diphtheria membrane) which had been incubated for three days at 37° C. On the second and as well on the third day, there was observed

a rise of temperature in the cows, but (*see* table in footnote) in another 24 hours it had again become normal, and subsequently remained so. On the third day the place of inoculation showed under the skin a soft tumour, tender to the touch; in one cow it was as big as a fist, in the other hardly so large. During the fourth, fifth, sixth, and seventh days the tumour increased in one animal (No. 1) to the size of an infant's head; in the other cow (No. 2) the tumour rather decreased in size. But in both cases by pressure, clear slightly sanguineous serum could be squeezed from it. In the second week the tumour of cow No. 1 slowly decreased and became firm; on cow No. 2 it decreased more quickly but to the 14th day a firm tumour could still be felt, at which date the epidermis over it was desquamating in large flakes.

Now, on the *fourth day* a remarkable appearance was for the first time noticed in cow No. 2, namely, the presence of a small vesicle on one hind teat and of other and similar vesicles on the udder near to it.

resulting udder eruption;

On the *fifth day* the vesicle on the teat was covered with a brown thin crust, the skin about which felt between the fingers like an indurated nodule. On more careful examination by "throwing" the animal, it was found that on the udder between and near to the hind teats there were present about a dozen roundish more or less acuminated vesicles, some still containing clear lymph, others purulent with darkish centre, and others again covered with brown crusts. Around each was a corresponding distinct nodular induration of the skin. All were slightly raised on a slightly injected corium. On removing one of the crusts an ulcer was exposed covered with purulent film. The pustules and crusted ulcers differed in size; some measured not more than an eighth of an inch in diameter, others measured as much as half an inch, or even more. As mentioned above most of them were on the udder between the hind teats, but there were some also on the outer surface of the udder near to the base of these teats.

On the *sixth day* the number of these "sores" was increased; some were vesicles with clear lymph, but those that were vesicles on the previous day had now become pustular, while the pustules of yesterday had already become covered with crusts. Of the new vesicles one was on a hind teat. Material (crusts and scrapings) from vesicles and pustules of this cow (No. 2) were now taken for further experiment.

The other cow (No. 1) was also carefully examined on this the *sixth day*, and on its udder four eruptive sores were found. One was a

| Date in 1890. | Temperature, in Degrees Centigrade of | | | | Date in 1890. | Temperature, in Degrees Centigrade of | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cow No. 1. | | Cow No. 2. | | | Cow No. 1. | | Cow No. 2. | |
| | A.M. | P.M. | A.M. | P.M. | | A.M. | P.M. | A.M. | P.M. |
| March 17th - | (inoculated 1 p.m.) | 39·0 | (inoculated 1 p.m.) | 38·6 | March 24th - | 38·6 | 38·4 | 38·8 | 38·6 |
| | | | | | „ 25th - | 38·6 | 38·6 | 38·6 | 38·7 |
| | | | | | „ 26th - | 38·6 | 38·6 | 38·6 | 39·0 |
| „ 18th - | 39·2 | 39·4 | 40·0 | 40·2 | „ 27th - | 39·0 | 39·4 | 38·4 | 38·6 |
| „ 19th - | 40·3 | 40·2 | 38·6 | 38·2 | „ 28th - | 39·2 | 40·0 | 38·5 | 38·8 |
| „ 20th - | — | — | — | — | „ 29th - | 39·6 | 39·8 | 38·8 | 38·2 |
| „ 21st - | 38·6 | 38·8 | 38·8 | 39·1 | „ 30th - | 39·2 | 39·8 | 38·6 | 38·4 |
| „ 22nd | 38·7 | 38·2 | 38·8 | 38·6 | „ 31st - | dead | | 38·6 | — |
| „ 23rd - | — | — | — | — | April 1st - | — | — | — | — |

beautiful vesicle about half an inch in diameter, slightly raised on a slightly injected corium; a second was a pustule, and other two were crusted ulcers, each about half an inch in diameter.

On the *eighth day* there appeared on cow No. 2 five fresh vesicles; no fresh eruptions on cow No. 1. The previously crusted ulcers of both cows were found to be healing, *i.e.*, they had diminished in size and were almost dry; but those of cow No. 2 that had been scraped were covered with fresh black crusts.

On the *tenth day* no new vesicles were to be seen on cow No. 2, and the most recent ones were diminished in size and drying up. In cow No. 1 some were almost dried up and were fast healing. Figures 65, 66, and 64 show the eruption in cow 2 on the sixth and eighth days.

We have, then, here a most notable result of this subcutaneous inoculation of the cow with the diphtheria bacillus. On the teats, and more markedly on the udder, we have the appearance of vesicles, pustules, and ulcers on an indurated and slightly injected corium; the eruption having, moreover, this peculiarity, namely, that it passed with great rapidity through its several stages:—thus, it was vesicle one day, a pustule the next day, and a crusted ulcer for only two to four days. The whole process was in fact completed in about 6–8 days. That the eruption was not due to mechanical injury of the cow's teats during milking must be obvious from its peculiar anatomical character, and from its remarkable regularity in origin, progress, and healing; moreover, the eruption was chiefly on the udder, only to very limited degree on the teats, and could not therefore be referred to the process of milking. As already stated, too, the udder and teats of both cows when received were perfectly clean, and remained so during twelve days previous to the appearance of the eruption. Now, this eruption simultaneously appearing in these two cows and possessing all the anatomical and clinical characters of a specific disease, was brought about in one or other of two ways. Either it was latent in the cows (as might have been cow-pox) when they were received at the Brown Institution: or it was the result of the inoculation of them with the bacillus diphtheriæ. The former explanation may be altogether excluded:—There certainly was no sign of anything abnormal noticeable on the udders of the cows for fully twelve days after their reception at the Brown Institution; nor on inquiry could anything be heard of any such illness amongst cows of the locality from which these two animals were obtained. Further, the character and progress of the eruption is obviously of a totally different nature from cow-pox or similar eruptive disease of the udder. There remains therefore only the second explanation, viz., that the eruption was the direct result of the experimental inoculation; indeed its appearance on the fourth or fifth, and continuance until the eighth day after the subcutaneous inoculation, is positive evidence in favour of such explanation. Viewed in this light "chaps," and scabs or crusts on the "chaps," in the Camberley cows appear to have real significance. An eruption passing off rapidly, as in my experimental cows, would not, after lapse of few days, necessarily be found on the Camberley cows. It is nothing, therefore, that the Camberley cows were found in good health on October 13 and 21. So were my cows within two weeks from development of their eruption; they at that time fed well, gave abundant and seemingly good milk, they ruminated well, and their temperature had become quite normal as early as the fourth day after inoculation. Nevertheless their eruption was really a result of the experimental inoculation of bacillus diphtheriæ, as was proved by the fact that *in the lymph of their induced*

brief duration thereof;

*vesicles and pustules the bacillus diphtheriæ could be demonstrated unmistakeably both in cover-glass specimens and by culture.*

bacillus diphtheria in the lymph of the induced vesicles

It may of course be objected that this general eruption on the udders of my cows was produced by direct contagion either by the hand of the milkers or otherwise; that it was due, for instance, to a direct inoculation of the skin of the udder with secretion from the primary seat of inoculation of the cows. I cannot, for obvious reasons, deny such possibility. I cannot of course say whether the attendants of the animals, who were also the milkers, did or did not contaminate their fingers with the secretion of the local tumour on the shoulder (the seat of the primary inoculation), and convey matter therefrom to the teats and udders of the cows. But I should in such case have expected the eruption to be especially on the teats instead of especially on the udder. Nor can I say whether or not the cow with her tongue or tail or in some other way herself transferred matter from the tumour on her shoulder to the skin of her udder. It is not possible absolutely to exclude such accident. But on the other hand it is demonstrable that these cows of mine suffered antecedently as well as subsequently to appearance of their udder eruption, from distinct constitutional malady induced, as I maintain, by my experimental inoculation. Thus:—(1.) These animals did show before the eruption appeared upon them, general symptoms,—in that they had febrile rise of temperature during the second and third day after inoculation. (2.) These animals coughed slightly while the eruption was manifesting itself. (3.) In the milk of the cow No. 2 I have conclusively demonstrated the presence of the bacillus diphtheriæ; and in the following fashion:—

indisposition of inoculated cow:

On the fifth day after inoculation, while the eruption in cow No. 2 was still in progress of appearing, I had a teat which was perfectly sound and altogether free from eruption well washed and scrubbed with soap and water, and washed finally with a strong solution of carbolic acid. Similarly the hands of a milker were thoroughly cleaned and disinfected. This having been done the milker began milking that teat, and during the process of his milking I received several strokes of the milk into a beaker previously sterilised, which beaker, immediately the milk was received into it, was covered up with sterile glass plate and taken to my laboratory. Of this milk one minim was rubbed over the slanting surface of the nutrient gelatine in each of four test tubes. On the third day, and more conspicuously still on the fourth and fifth days, three of the four tubes showed colonies. The fourth tube remained barren of growth; the others showed—one tube two colonies, other two tubes three colonies each. In none of these tubes were any other and contaminating organisms present at any time while under observation. All eight colonies were of the same kind, and, as microscopic examination and subcultures proved, were *unmistakeably colonies of the bacillus diphtheriæ.* (Figures 53, 54, and 55.) The morphological characters of these bacilli from the milk were exactly the same as regards size and aspect as those from human diphtheria.

her milk contained bacillus diphtheriæ.

Thus, then, it was proved that the bacillus diphtheriæ subcutaneously inoculated into the shoulder of the cow, *was received into the system of the cow, produced the eruption on the udder, and was finally excreted in the cow's milk.* The number of the bacilli in the freshly drawn milk was, however, comparatively small, since from four minims of milk there were produced only eight colonies,—*i.e.*, 32 colonies per cubic centimetre. This,—reckoning, in illustration, each colony as started by a single bacillus,—would give some 30,000 to 40,000 bacilli in a litre

(1·76 English pints) of milk; a number sufficient, however, to have hit with diphtheria a number of persons partaking of the milk, with allowance at the same time for a considerable per-centage of misses.

Now, on a former page I have shown that milk kept at 19–20° C. is a medium wherein the diphtheria bacillus multiplies readily, and we can therefore easily understand how such milk as the sample just referred to might, when "stored," become additionally infective. Similarly, certain facts of the Camberley outbreak, namely, that more people were hit with diphtheria in better-class houses than in houses belonging to the poorer class, become easy of apprehension. For, as we are told, persons of the former class habitually took in large quantities of milk and "stored" it, whereas the poorer people, as a rule, took in milk in a small quantity only, and for immediate consumption.*

Pathology of induced cow disease;

There remains to be recorded the further history of these cows. Cow No. 1 was found very ill on the 13th day after inoculation. It did not feed or ruminate, had fallen away very conspicuously, drank no water at all, and its breathing was rapid. The secretion of its milk, too, had almost entirely ceased, and its fæces were scanty and firm, like horses' fæces. On the next (14th) day, when it had but one scab left on the udder with much induration of the corium, its general condition was worse than on the preceding day. It died during the night of the 14th–15th day. On *post-mortem*:—At the seat of inoculation there was observed over a space of 4 inches a flat thickening of the integuments, including the skin and subcutaneous and adjoining muscular tissue, to the depth of about 2 inches. On cutting through the mass the epidermis was found brittle and easily crumbled away. In the tumour were subcutaneous laminæ of white necrotic tissue, clear fluid oozing here from the incision. Near the tumour was a huge lymph gland, showing petechiæ in its cortical portion, and adjoining it were five or six small glands, the size of a pea to a bean, of deep red, almost black, colour. No change was noted in the organs of throat. The upper lobes of both *lungs*, and the upper back portion of the other lobes, were deeply congested, and there were also petechiæ on the pleuræ. The lymphatics of the pleura-pulmonalis were distended by clear lymph, and showed over many lobules as a prominent dense network (Fig. 68). On the outer surface of the parietal pericardium was a patch of hæmorrhage; the tissue around it was œdematous. The visceral *pericardium* of the ventricles and auricles showed hæmorrhagic patches and spots (Fig. 72). The *liver* showed on the right lobe numerous roundish or angular depressed, grey, necrotic patches (Fig. 71); on section these were found to extend into the depth of the tissue. The size of the patches varied from that of a pin's head to half an inch in diameter. Both *kidneys* were greatly congested in their

* With reference to diphtheria infection in milk, and as illustrating the susceptibility of the conjunctiva and cornea to diphtheritic inflammation, the following note by Mr. Brudenell Carter, and which I have his permission to make public, is of particular interest:—"A healthy child, when about a fortnight old, had what was "described as a trivial conjunctivitis, and which was certainly not the ordinary "purulent ophthalmia of infancy, the time for which had passed away. The case "was so slight that the doctor was not sent for, but the nurse bathed the eyes with "some of the cow's milk which was then in use in the family. The inflammation "speedily assumed a character of great severity, and was pronounced by the doctor "to be diphtheritic. Both corneæ perished. I did not see the case at this time, "but six months later, when I was consulted about the resulting staphylomata. I "can only conjecture that milk which was harmless to those who swallowed it was "yet able to excite diphtheria in a membrane rendered vulnerable by slight "inflammation."

whole thickness, and there were petechiæ in the cortex. The *spleen* was not congested nor enlarged, but in the capsule were numerous prominent thickenings like greyish-white streaks and patches anastomosing with one another (Fig. 70). On the udder there was a scab covering an ulcer; the skin here being much indurated. Another scab was loose, the ulcer under it being almost healed and dry.

In cow No. 2 by the 14th day all scabs but two had come off, and places whence they had fallen were healed; the tumour over the left shoulder was firm, and the epidermis over it was coming off in big flakes. The animal seemed at this date otherwise right; its temperature was normal, it fed well, it ruminated and gave plenty of milk. As time went on, however, its cough increased and it appeared to lose flesh. Suddenly, about the twenty-fourth day, it became much fallen in, breathed very rapidly, and ceased feeding and ruminating. It was killed on the twenty-fifth day. *Post-mortem*:—At the seat of inoculation there was a firm round tumour, about 2 by 2 inches, with œdema around it. This tumour involved the subcutaneous and muscular tissue, and when cut into showed a number of necrotic white septa between which the bundles of muscular tissue (some themselves also necrotic, others normal), could be discerned. The nearest lymph gland was much enlarged, juicy, and contained petechiæ in the cortex and medulla. The udder and teats were quite clean. Both *lungs* showed the upper lobes and a portion of the adjacent lobes much congested, with grey solidification around the bronchi. The pleural lymphatics were well marked as a network of red streaks, containing much sanguineous lymph (Fig. 69). In the upper lobe of the left lung was a consolidated patch about the breadth of the palm of the hand, which when cut into exuded a large amount of sanguineous serum. The *pleura* and the interlobular septa of the lung were very œdematous. The *bronchial lymph glands* were swollen and œdematous. In the *liver* were a few brownish necrotic patches. Both *kidneys* were much congested in the medulla, and showed a few fatty patches in the cortex.

Cultivations were made with material from the tumours of both cows, and the diphtheria bacillus was obtained in innumerable colonies alike on Agar and on gelatine. No other microbe appeared in these cultures; they were purely cultures of bacillus diphtheriæ. The morphological and cultural characters of the bacillus thus obtained from the local tumours of the cows were indeed identical with those of the human diphtheria bacillus.

its microscopic anatomy.

Microscopic sections made through the substance of the tumour showed necrotic reticulated masses (the white septa already referred to) containing large and small aggregations of the diphtheria bacilli (*see* Figures 48 and 49). These aggregations of bacilli extended into the muscular tissue nearest to the septa, in fact the implication of the muscular fibres by gradual growth into them of the masses of bacilli could be easily traced (Figs. 58, 59, and 60). Further careful microscopic examination of the masses of bacilli in the necrotic portions of the tumour, as also of those implicating the muscular fibres, revealed the following remarkable fact, namely, that many bacilli had become threads, some of considerable length, and containing granules in their course, characterised by intermediate or terminal buds or swellings, spherical, oval, or flask shaped. In a word, the organisms had taken on forms which are but exaggerations of what had been before observed in cultures of this bacillus. I draw particular attention to the bacilli cultivated from the milk of the cow No. 2 (*see* Figs. 54 and 55), where some of the threads were seen to be

possessed of terminal flask-shaped enlargements reminding one vividly of the growing and germinating hyphæ of a mycelial fungus. That these threads in the tissue of the tumour had been really developed from the diphtheria bacilli was proved by the circumstance that all intermediate forms between the typical diphtheria bacillus and these hyphæ-like threads could be everywhere seen in the same microscopic section; and as well by the fact that every one of colonies in the cultures obtained from the tumour were found to be pure diphtheria bacilli. [In this connexion I may state that I have complete evidence that tubercle bacilli in old cultures develop also into branched hyphæ which are indistinguishable from mycelial hyphæ, and I illustrate this by the three figures (61, 62, and 63). That the branched threads here depicted have been real tubercle bacilli is proved by the fact that they are invariably present in the colonies of Agar-glycerine cultivations after several weeks or months, while on the other hand there can be no question that the colonies whence they were derived have been throughout pure tubercle bacilli without admixture of other organisms.]

As was mentioned on page 169 scrapings of the eruption of cow No. 2 were taken on the sixth day after inoculation for use in further experiments.

Transmission of cow disease to calves;

With these scrapings, two calves (Nos. 1 and 2) were inoculated into cutaneous incisions of the belly and groin. On the fifth and sixth days thereafter, there appeared in each calf at the site of these incisions a limited number of red papules. On the eighth day I noticed in calf No. 1, two vesicles each $\frac{1}{3}$–$\frac{1}{2}$ inch in diameter, and several smaller vesicles, as having succeeded to papules. Calf No. 2 had at the same date one good vesicle. Thenceforward the eruption on these two calves proceeded in much the same fashion as in the case of the cows themselves, except that new vesicles appeared daily till the eighteenth day. As before, the vesicle of one day became a pustule on the next day, and was converted into a brown crust on the day following. These crusts enlarged for two or three days, and then became loose and fell off. Figure 67 is an accurate representation of the condition of one of the calves on the twelfth day.

Concurrently with full development of their vesicular eruption, namely, about the tenth or eleventh day, the calves were noticed to cough a good deal and to breathe rapidly. At the same time there was in each calf muco-purulent discharge from the nose, and the animals were off their feed. The lung trouble next increased, and the animals so far lost flesh as to be obviously in poor condition, though their temperature did not become materially altered. Both animals were killed on the 25th day.

On *post-mortem* the skin of the groin and belly was in both calves now free from eruption or crusts; but the *inguinal lymph glands* were enlarged and œdematous. The upper lobe and the upper portion of the adjacent lobe of *both lungs*, in both calves, showed consolidation (Fig. 73); the lung tissue being generally much congested, with lobular broncho-pneumonia. Pieces of the more solid parts of the lung sunk in water. In both calves the *kidneys* showed in some lobes well-marked fatty degeneration of the cortex. (*See* Figs. 74 and 75.)

and incidentally to cats.

While the above investigations were proceeding, another and very interesting experiment (but one not instituted by me) had been in progress at the Brown Institution. There occurred at the beginning of April two deaths of cats kept there in a special shed by Professor Horsley for use as occasion required, for his laboratory purposes. The cats in

question had been obtained three or four weeks previously, and they had remained in perfect health until the last week of March, when they suddenly sickened, and after an illness of 3–4 days died. Their illness was acute catarrhal affection of the conjunctiva, and of the respiratory passages, during which they were quiet and did not feed. During the illness, and after the death of these two cats (Nos. 1 and 2), every cat procured for Professor Horsley and put into the same shed (though perfectly well on arrival) sickened in the same way as the above animals; with the result that during April and the beginning of May, 14 additional cats gradually became ill. Of these 14 animals, 5 died, the others gradually recovered. The symptoms were in all the same :— running of eyes, with in some muco-purulent discharge from the conjunctiva; sneezing and coughing, the animals becoming quiescent and not taking their food. In some cats the pulmonary trouble increased and the animals became much emaciated, very weak, and ultimately died. One week to three weeks was the duration of the illness in these cats.

In all fatal cases, the prominent pathological changes were lobular pneumonia and large white kidneys,—the entire cortex being in a state of fatty degeneration. In one of the cats the mucous membrane of the lower portion of the larynx, and of the upper part of the trachea was converted into and covered with a true grey diphtheritic membrane; in another cat the trachea contained muco-purulent matter. In all, the bronchi and infundibula contained fibrinous exudation. Under the microscope, the appearances were the same as in the cats mentioned on a former page. In the particular cat in which there was in the larynx and trachea true diphtheritic membrane, the microscope showed *crowds of the diphtheria bacilli* as smaller or larger groups *in the necrotic mucous membranes*. Similarly in the exudation from the bronchia and trachea of another of the above cats, the diphtheria bacillus could be demonstrated.

From the above description of the symptoms and of the pathological appearances at the post-mortem examination, it is clear that in this epidemic of cat disease at the Brown Institution we had to deal with precisely the same disease that has been described in this report as occurring naturally in the cat, and as inducible in that animal by inoculation of diphtheria material. The symptoms during life, and the condition after death of the lung and kidneys suffice indeed to conclusively prove this.

The question now arises how did this cat epidemic at the Brown Institution originate? As has been stated above the two cats (Nos. 1 and 2) that sickened in the last week of March started the epidemic, and the disease afterwards spread from animal to animal so long as cats continued to be brought into and kept in the shed in question. No cat had sickened or died in this shed for several months antecedent to the sickness and death of cats Nos. 1 and 2, and these two cats had themselves been perfectly well up to the last week of March. It was about the 21st of March that the eruption was first noticed on the udder of the cow mentioned on page 169, and at the same time its milk was found to contain the diphtheria bacillus (*see* p. 171).

through the medium of the milk of the experimental cows.

Now the cows upon which I was experimenting with cultures of the diphtheria bacillus were kept in the stables of the Brown Institution in a different part of the establishment altogether from the shed in which Professor Horsley's cats were kept. And as soon as the eruption

appeared on the udder of the cows I gave strict orders (having in my mind risk to the human subject) to the attendant that the milk of the cows should be thrown away. But this order was not fully carried out, as appeared afterwards. A portion of the milk had thenceforward continued to be given to those two cats Nos. 1 and 2, and seeing that commencement of illness of these two cats followed within a very few days the ascertained presence of the diphtheria bacilli in the milk of the cows, there is, I think, strong presumption that the consumption of this milk by the cats was the cause of their illness. The circumstance that the same man who attended on the cows attended also on the cats, by no means sets aside such presumption. This person was himself certainly free from any disease, and I regard it as improbable that he casually conveyed on his person infective matter directly from the cows at one part of the establishment to the cats at another and different part of it.

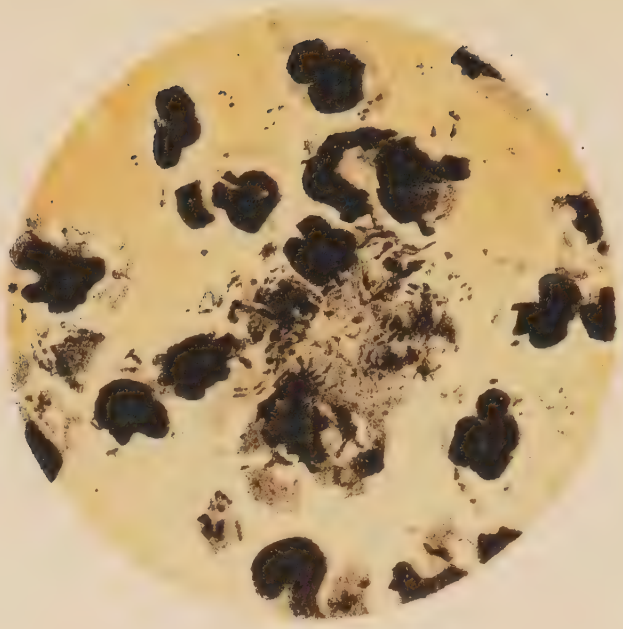

Fig. 1.

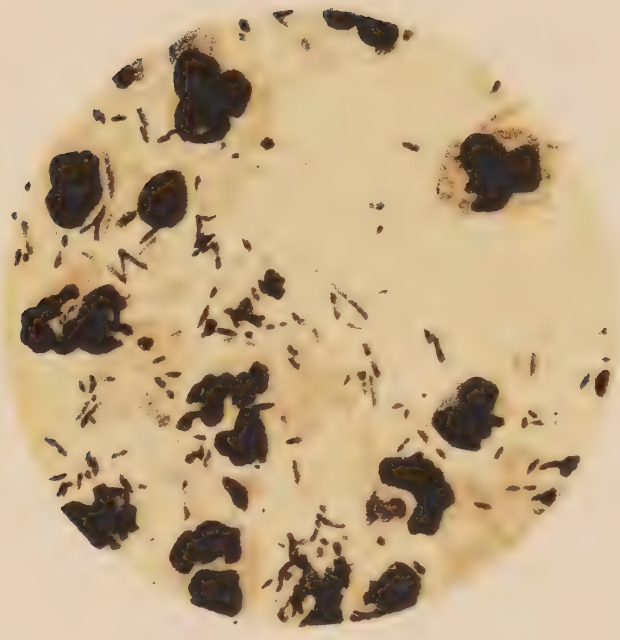

Fig. 2.

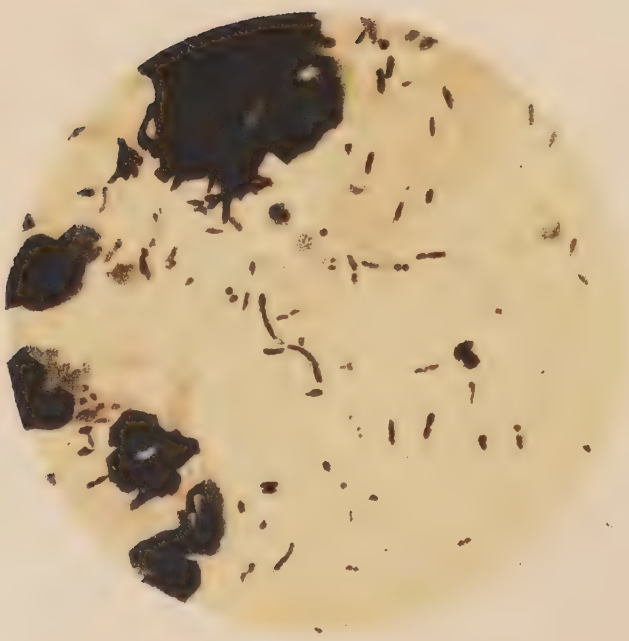

Fig. 3.

# ETIOLOGY OF DIPHTHERIA.

## PLATE I.

FIGS. 1, 2, and 3.

Reproduced from photographs of stained cover-glass specimens of material from the fresh diphtheria membrane of a child. The photographs showed nuclei as deeply-stained masses, with the diphtheria bacilli numerously scattered over the field. Nutrient media inoculated with material from the same source showed on incubation the diphtheria bacilli in *pure* culture.

In fig. 1, there is seen a large group of the diphtheria bacilli lodged in a mass of cell débris.

Magnifying power 1,000.

[The representations here made fail in reproducing the points of the original photographs.]

## ETIOLOGY OF DIPHTHERIA.

### PLATE II.

FIGS. 4, 5, and 6.

Reproduced from photographs of stained cover-glass specimens of material from cultures on *Agar* of the diphtheria bacillus from a human source.

In the photographs the forms of the bacilli, particularly in figs. 5 and 6, were very characteristic.

Magnifying power 1,000.

[As here reproduced most of the bacilli have a double outline.]

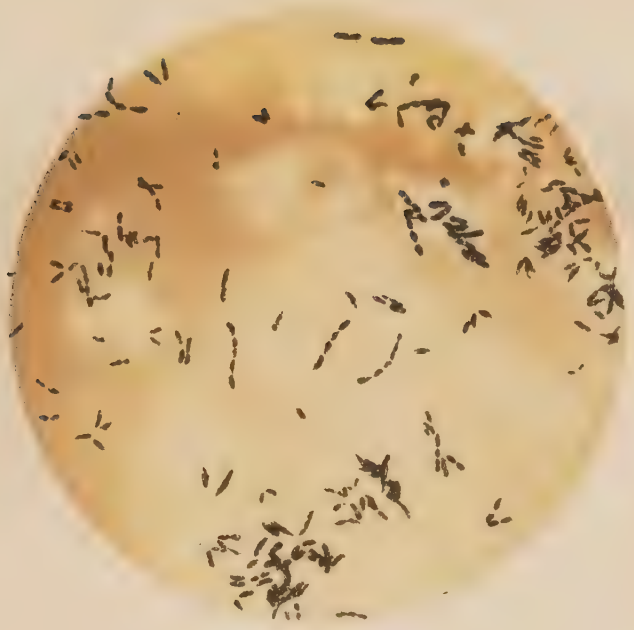

Fig. 4

Fig. 5

Fig. 6.

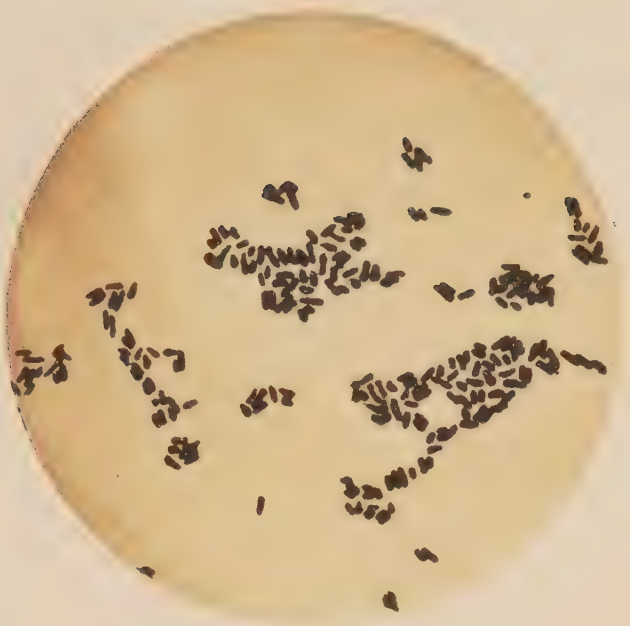

Fig. 7.

Fig. 8.

## ETIOLOGY OF DIPHTHERIA.

### PLATE III.

FIGS. 7 and 8.

Reproduced from photographs of the diphtheria bacilli in stained cover-glass specimens from a sub-culture on nutrient *gelatine* incubated at 20° C. The bacilli in this (gelatine) sub-culture were shorter and thicker than in sub-culture on Agar, and many of the organisms were conical.

Magnifying power 1,000.

[The representation here made fails in reproducing the points of the original photograph, particularly as regards fig. 7, wherein almost every bacillus was seen to be conical.]

## ETIOLOGY OF DIPHTHERIA.

### PLATE IV.

FIG. 9.

Represents a section through a diphtheria membrane from the tonsil of a child. The necrotic superficial ground substance of the membrane, as well as its deeper portion containing nuclei, is stained with rubin. The blue masses (stained with methyl-blue) are clumps and masses of the diphtheria bacilli; densely packed near the surface (right of the drawing), and diminishing in number in the deeper layers.

Magnifying power 100.

Upon culture, the clumps and masses above referred to were demonstrated to be almost entirely made up of the diphtheria bacilli.

FIG. 10.

Represents a similar preparation to the above more highly magnified. It shows the masses of diphtheria bacilli in the deeper parts of the false membrane, along with remnants of nuclei.

Magnifying power 700.

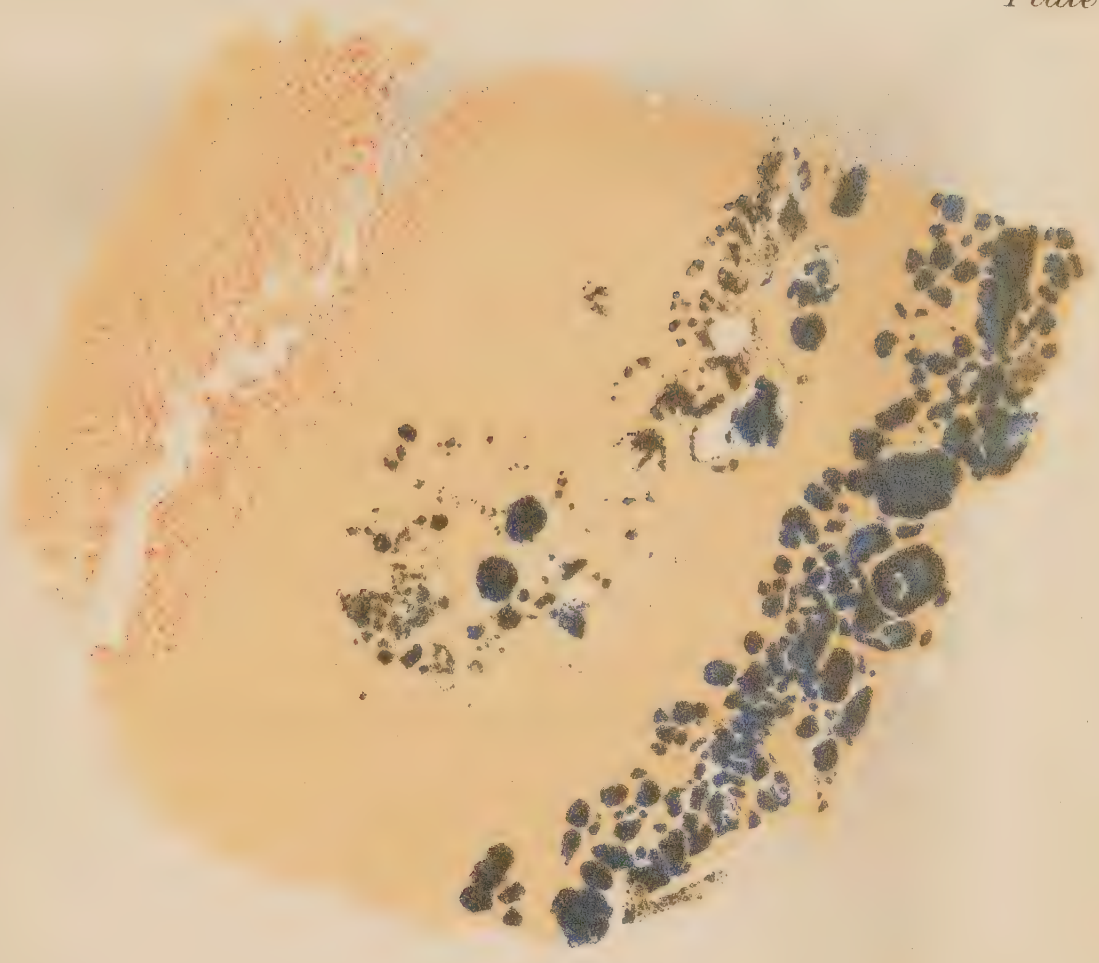

Fig. 9.

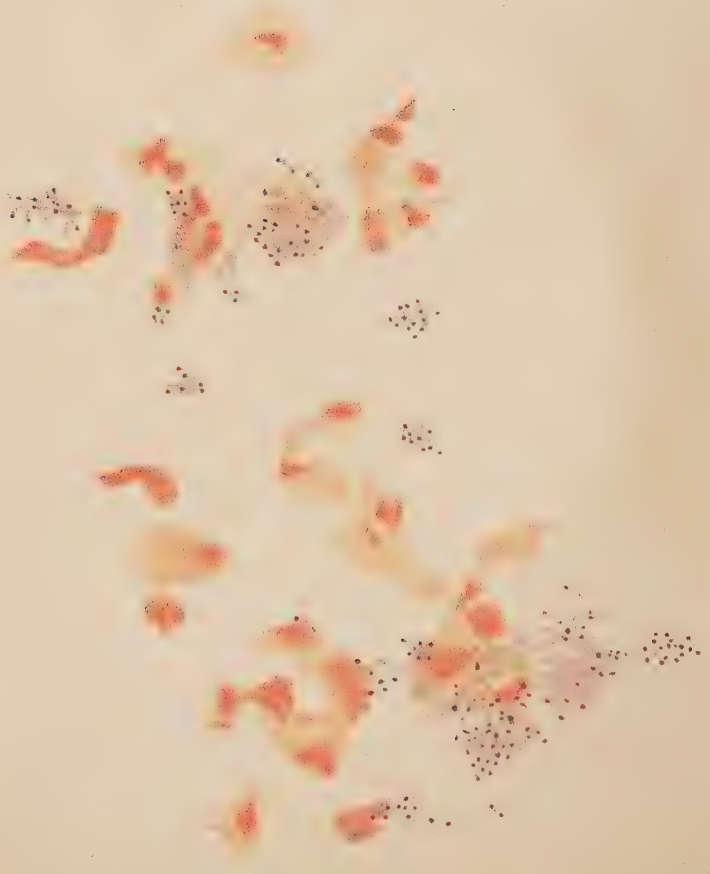

Fig. 10.

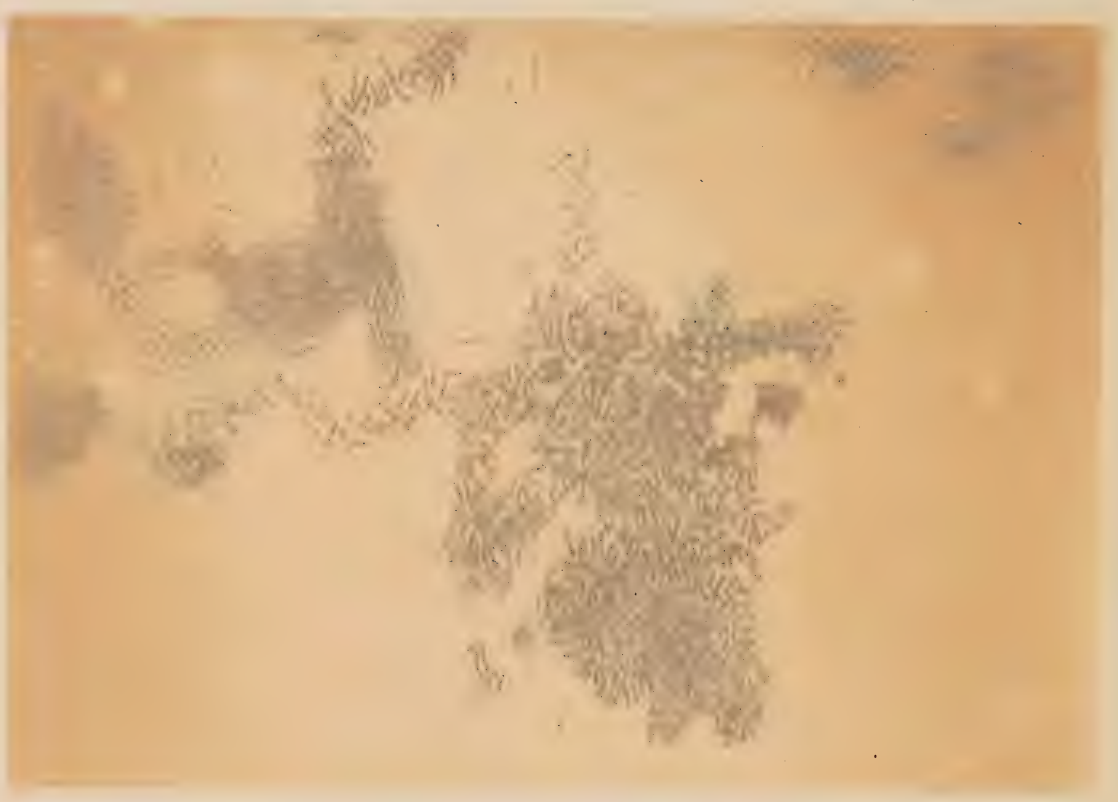

Fig. 11.

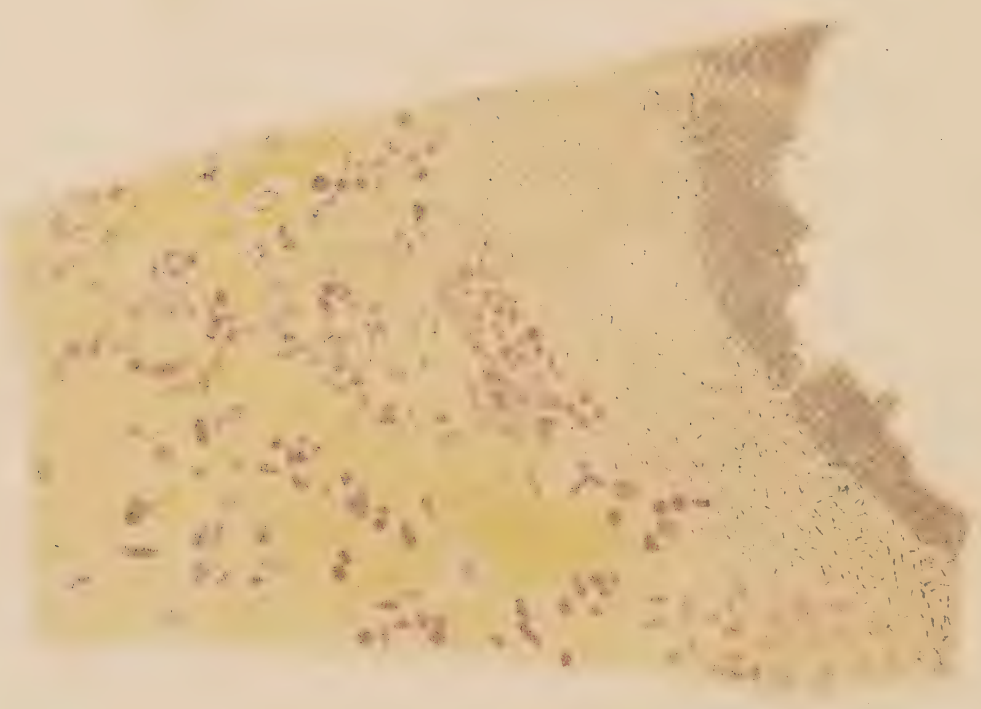

Fig. 12.

## ETIOLOGY OF DIPHTHERIA.

### PLATE V.

FIG. 11.

Represents a section (stained in rubin and methyl-blue) through the diphtheria membrane of a child. The masses of the diphtheria bacillus here shown were in the superficial parts of the membrane.

Magnifying power about 1,000.

FIG. 12.

Represents a section (stained in gentian-violet) through the mucous membrane of the pharynx of a child dead of acute diphtheria. On the right of the figure is seen the surface of the false membrane, on the left the mucous membrane itself undergoing necrotic change. This tissue is full of effused blood and contains remnants of nuclei. The surface is crowded with the diphtheria bacilli, and in the subjacent part the bacilli are very numerous and almost in *pure* culture.

Magnifying power 300.

## ETIOLOGY OF DIPHTHERIA.

### PLATE VI.

FIG. 13.

Represents a section (stained in gentian-violet) through the superficial part of the mucous membrane of the pharynx of a child dead of acute diphtheria. The upper margin of the figure corresponds to the free surface of the false membrane, the lower part to the mucous membrane still showing tissue cells and nuclei. The false membrane is pervaded by diphtheria bacilli in *pure* culture.

Magnifying power about 1,400.

Fig. 13.

M. H. Lapidge.

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Fig. 14

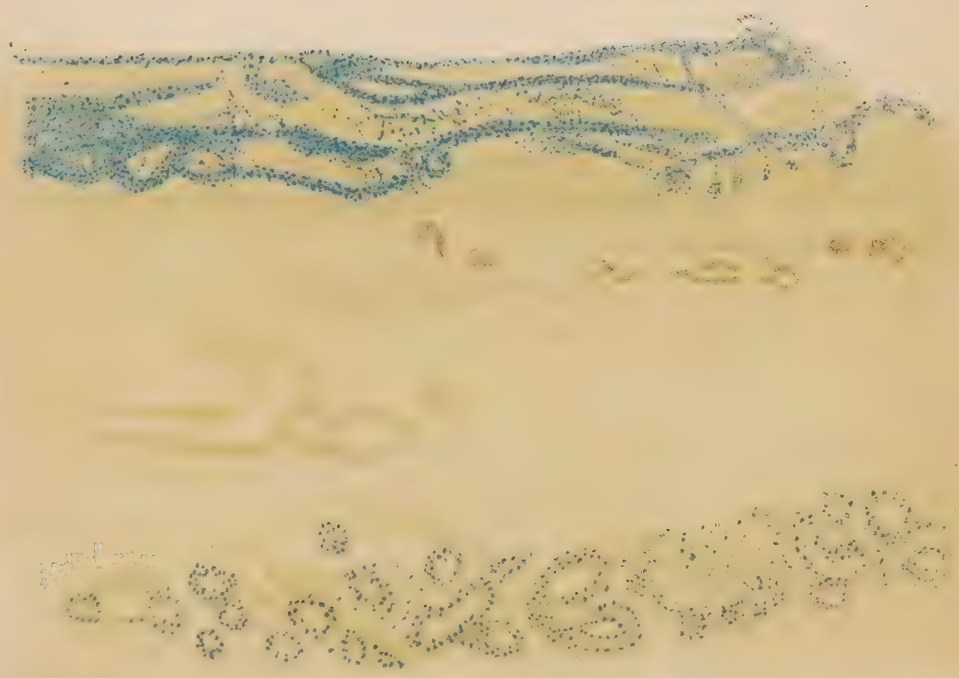

Fig. 15.

## ETIOLOGY OF DIPHTHERIA.

### PLATE VII.

FIG. 14.

Represents a portion of the same section depicted in Plate VI. It shows a mass of diphtheria bacilli in a part of the mucous membrane immediately below that represented in Fig. 13.

Magnifying power 700.

FIG. 15.

Represents a section through the larynx of a child dead of acute diphtheria. In this case the diphtheritic condition of the mucous membrane involved the fauces, pharynx, and the whole of the larynx; a thin false membrane extending also into the upper third of the trachea.

The upper portion of the figure corresponds to the free surface of the diphtheria membrane. In it are continuous masses of the diphtheria bacilli, stained blue. At its lower part are numerous glands of the submucous tissue. The intervening mucosa is necrotic, and in it are seen a few vessels in section.

Magnifying power 100.

## ETIOLOGY OF DIPHTHERIA.

### PLATE VIII.

FIG. 16.

Represents the superficial portion of the false membrane depicted in fig. 15, more highly magnified.

Magnifying power 700.

FIG. 17.

Represents a cover-glass specimen (stained in rubin and methyl-blue) of material taken after death from the diphtheria membrane in the pharynx of a child. The diphtheria bacilli here were in *pure* culture, some of the cells being filled with and almost destroyed by these organisms.

Magnifying power 700.

Fig. 16

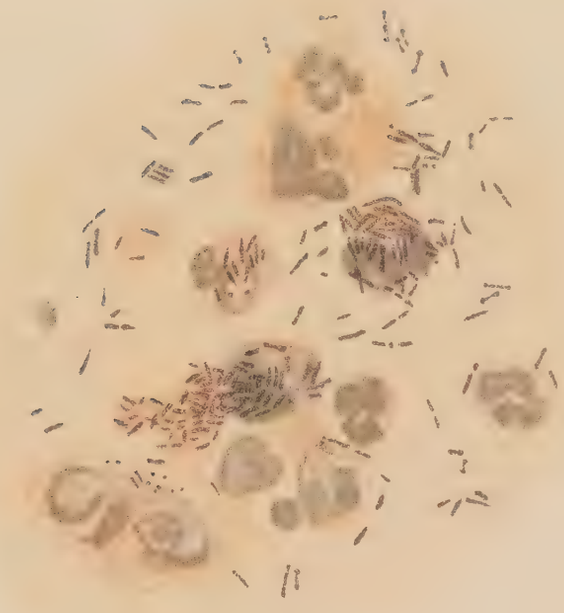

Fig. 17

Fig. 18.

Fig. 19

Fig. 20.

M.H. Lapidge.

Judson & Co. Lith. 73 & 75, Farringdon Rd & Doctors' Commons

## ETIOLOGY OF DIPHTHERIA.

### PLATE IX.

FIGS. 18 and 19.

Represent colonies, *on the surface* (set slantingly) of *Agar* mixture, of the diphtheria bacilli derived directly from fresh diphtheria membrane from the fauces of a child. Appearance after *two weeks* incubation at 37° C.

Natural size.

FIG. 20.

Represents a similar culture *on the surface* (slanting) of nutrient *gelatine*. Appearance after *two weeks* incubation at 20·5° C.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE X.

FIGS. 21, 22, and 23.

Represent colonies, *on the surface* (slanting) of nutrient *gelatine* in three different tubes, of the diphtheria bacillus directly derived from fresh diphtheria membrane of the human subject,

Fig. 22, appearance after *one week;* incubation at 20·5° C.
Fig. 23, ,, ,, *two weeks;* ,, ,, ,, ,,
Fig. 21, ,, ,, *three weeks;* ,, ,, ,, ,,

Natural size.

Fig. 21.

Fig. 22

Fig. 23.

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Fig. 24.

Fig. 25

Fig. 26.

M.H. Lapidge.

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## ETIOLOGY OF DIPHTHERIA.

### PLATE XI.

FIGS. 24 and 25.

Represent colonies, *on the surface* (slanting) of nutrient *Agar*, of the diphtheria bacillus directly derived from fresh diphtheria membrane of the human subject. Appearance after *two weeks* incubation at 36–37° C.

Natural size.

FIG. 26.

Represents a *streak* sub-culture of the diphtheria bacillus *on the surface* of nutrient *gelatine*, after *two weeks* incubation at 20·5° C.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XII.

FIG. 27.

Represents a *stab* culture of the diphtheria bacillus in nutrient *gelatine*, after *two weeks* incubation at 20° C.

Natural size.

FIGS. 28 and 29.

Represent colonies, *on the surface* (slanting) of nutrient *gelatine*, of the diphtheria bacillus recovered *post-mortem* from the induced sub-cutaneous tumours of different guinea-pigs dead 30 hours after inoculation with culture of bacillus diphtheriæ from a human source.

Fig. 28, appearance after *six days* incubation at 20·5° C.

Fig. 29, ,, ,, *seven days* ,, ,,

Natural size.

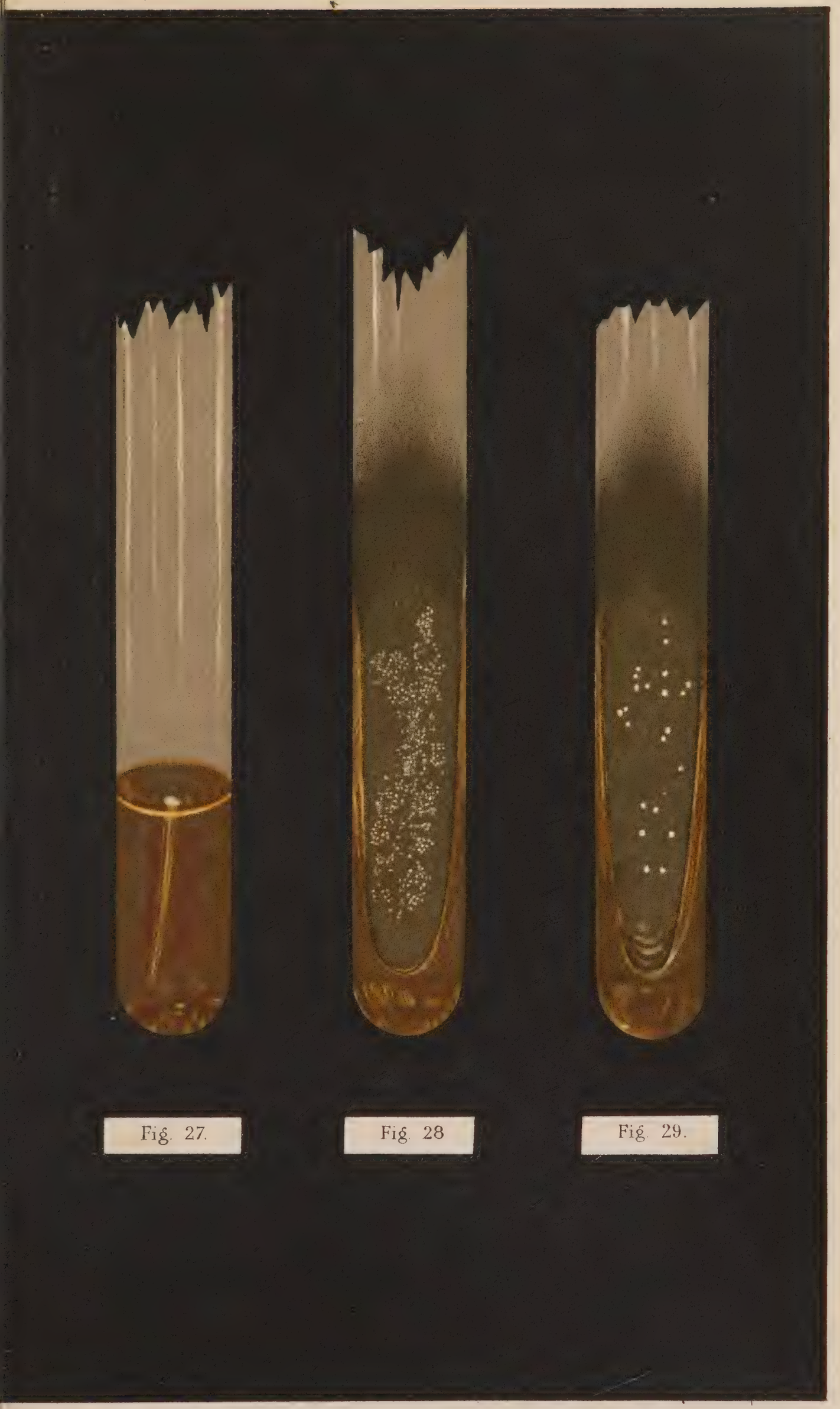

Fig. 27.

Fig. 28

Fig. 29.

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Fig. 30.

Fig 31.

Fig. 32.

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## ETIOLOGY OF DIPHTHERIA.

### PLATE XIII.

FIGS. 30 and 31.

Represent colonies, *on the surface* (slanting) of nutrient *gelatine*, after *two weeks* incubation at 20° C., of the diphtheria bacillus derived directly from the induced sub-cutaneous tumours of different guinea-pigs that had died 30 hours after inoculation with culture of bacillus diphtheriæ from a human source.

Natural size.

FIG. 32.

Represents a *streak* sub-culture, *on the surface* (slanting) of nutrient *gelatine*, after *two weeks* incubation at 20·5° C., of the diphtheria bacillus, derived from a culture of bacillus diphtheriæ obtained from the sub-cutaneous tumour of an experimental guinea-pig.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XIV.

FIGS. 33 and 34.

Represent colonies, from a plate cultivation on nutrient *gelatine*, of the diphtheria bacillus directly derived from fresh diphtheria membrane in the human subject.

Fig. 33, appearance after *ten days* incubation of 20° C.
Fig. 34, ,, ,, *three weeks* ,, ,,
Magnified ten times.

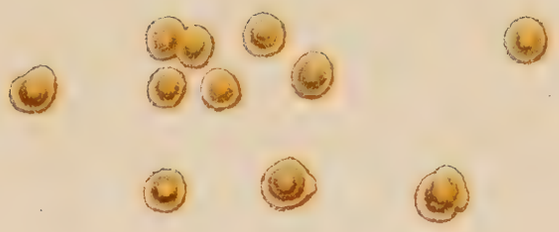

Fig. 33.

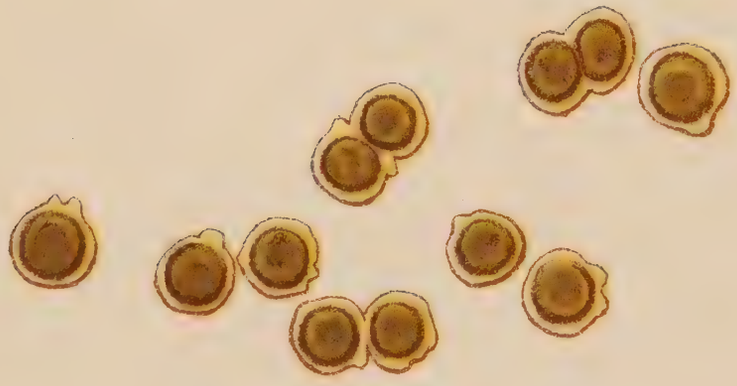

Fig. 34.

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apidge.

Fig. 35

Fig. 36

Fig. 37

M.H.Lapidge

## ETIOLOGY OF DIPHTHERIA.

### PLATE XV.

FIGS. 35, 36, and 37.

Represent different stages of the ulcer inducible on *the cat's cornea* by inoculation of the corneal tissue with the diphtheria bacillus from a human source.

Fig. 35 shows, several days after inoculation, a small crater-like ulcer of the cornea surrounded by grey, loosened, and swollen corneal tissue.

Fig. 36 shows, about 17 days after inoculation, the whole centre of a cat's cornea transformed into an ulcer, which penetrates as deeply as Descemet's membrane.

Fig. 37 shows, 16 to 18 days after inoculation, the centre of a cat's cornea ulcerated and bulged out as staphyloma. On the cornea, as also at its margin, pannus has developed.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XVI.

FIG. 38.

Represents the *kidney* (actual size) of a cat that died of diphtheria *induced in her* by inoculation of the diphtheria bacillus from a human source. This kidney, which was larger than normal, showed congested medulla and fatty cortex. On the left of the figure is represented a portion of the same kidney as it appeared under a magnifying glass.

FIG. 39.

Represents the *kidney* (actual size) of a cat that died after ten to twelve days illness of diphtheria disease *naturally acquired by her*. In this kidney enlargement of the cortex and fatty degeneration thereof is very conspicuous.

Fig. 38.

Fig. 39.

M. U. Lapidge

Fig 40

Fig 41

## ETIOLOGY OF DIPHTHERIA.

### PLATE XVII.

FIGS. 40 and 41.

Represent the *kidneys* of different cats that died in 5–6 days of illness resulting from inoculation into them of the diphtheria bacillus. In these drawings the congested medulla of the kidney and its enlarged and fatty cortex are well delineated.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XVIII.

FIG. 42.

Reproduced from a photograph of a section through the inflamed lung of a cat that died of naturally acquired diphtheria in a house wherein unquestionable diphtheria afterwards attacked children of the household. The bronchi, infundibula, and air cells were observed to be filled with exudation which, more highly magnified, had the character of necrotic tissue.

Under a low power.

FIG. 43.

Reproduced from a photograph of a section through a large bronchial tube, and the lung tissue adjacent to it, of a cat that had died 26 hours after injection into its trachea of a culture of the diphtheria bacillus. The bronchus and air cells were observed to be filled with necrotic exudation.

Under a low power.

[This lithograph fails to do justice to the photograph which was a particularly good one.]

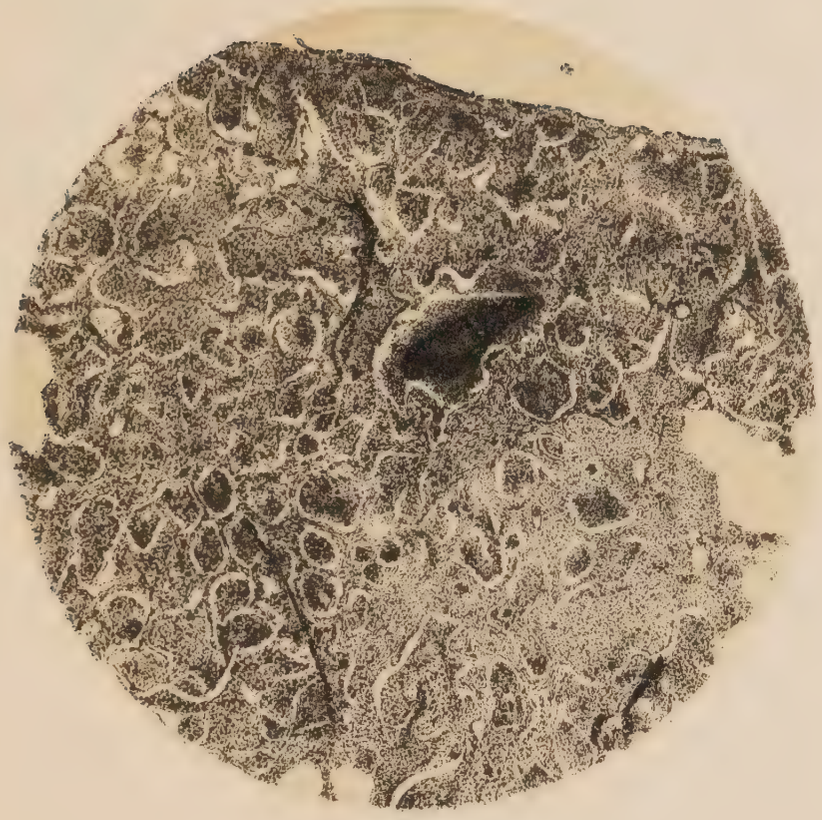

Fig. 42.

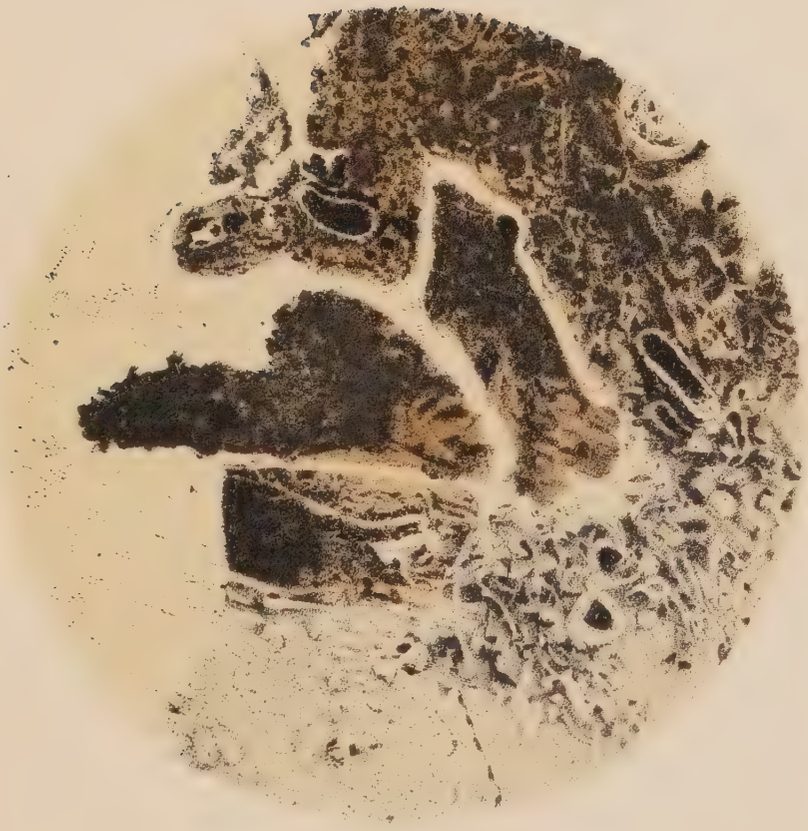

Fig. 43.

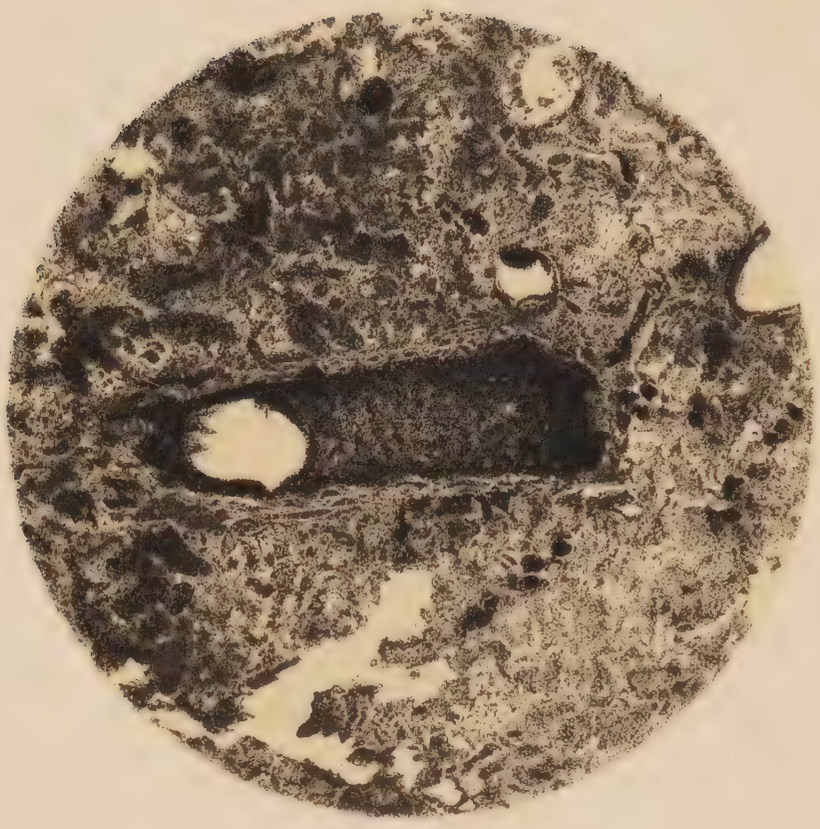

Fig. 44.

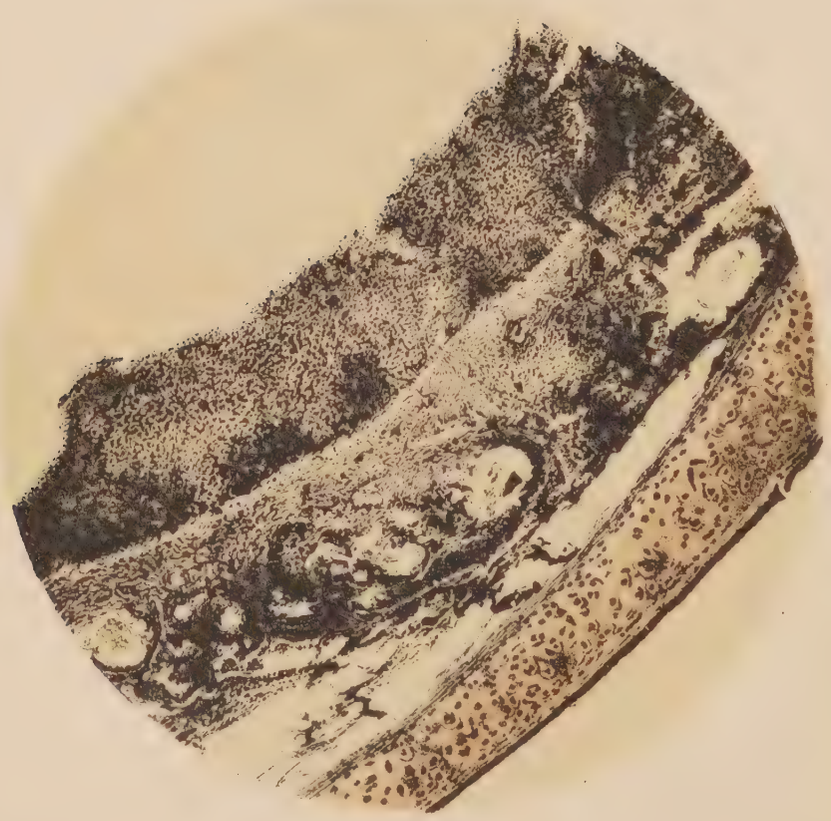

Fig. 45.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XIX.

FIG. 44.

Reproduced from a photograph of a section through a large bronchus, and the lung tissue adjacent to it, of a cat which was killed on the sixth day subsequent to injection into the cavity of its trachea of a culture of the diphtheria bacillus. The large bronchus in the centre of the figure and the air cells adjacent to it were observed to be filled with exudation which had undergone necrotic change.

Under a low power.

FIG. 45.

Reproduced from a photograph of a section through the larynx of a cat that died of diphtheria acquired in common-place fashion by infection from one of the cats that obtained diphtheria through drinking the milk of cow No. 2. The larynx was found lined with a diphtheritic false membrane; and the whole mucosa was observed to be converted into a diphtheritic layer, the sub-mucous tissue between the mucosa and the cartilage of the larynx being densely infiltrated with inflammatory products.

Under a low power.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XX.

FIG. 46.

Represents a cover-glass specimen of fresh lung exudation from the cat referred to under fig. 43. It exhibits epithelial scales, red blood-corpuscles, and many diphtheria bacilli.

Magnifying power 1,000.

FIG. 47.

Represents a cover-glass specimen of fresh lung exudation from the cat referred to under fig. 44. It exhibits nuclei and epithelial scales, a multitude of diphtheria bacilli, and a few streptococcus chains.

Magnifying power 700.

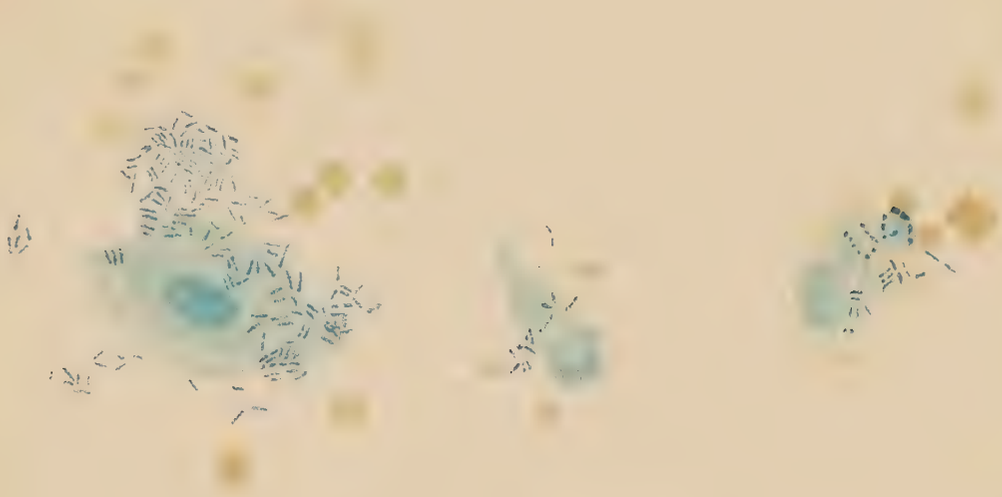

Fig. 46.

Fig. 47.

Fig. 48.

Fig. 49.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXI.

FIG. 48.

Reproduced from a photograph of a section through the subcutaneous tumour locally induced in cow No. 2 by inoculation behind her shoulder of a culture of the diphtheria bacillus. In the centre of the figure is a large and obliterated vessel cut across. Around this vessel is a mass of necrotic tissue. Above and below are muscular fibres.

Under a low power.

FIG. 49.

Reproduced from a photograph of the section depicted above. At the centre of the figure the tissue is necrotic, and in this necrotic tissue are deeply stained clumps and masses of the diphtheria bacillus. To the right of the figure are muscular fibres.

Under a low power.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXII.

FIG. 50.

Reproduced from a photograph of a cover-glass specimen of the diphtheria bacillus from an *Agar* culture derived from the necrotic tissue of cow No. 2 depicted in figs. 48 and 49.

Magnifying power 1,000.

FIG. 51.

Reproduced from a photograph of a cover-glass specimen of the diphtheria bacillus from a *gelatine* culture derived from the same source as the above.

Magnifying power 1,000.

Fig. 50.

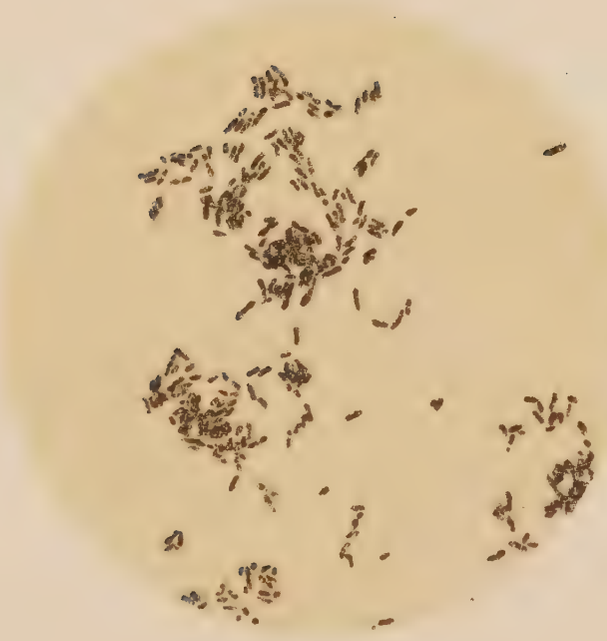

Fig. 51.

Fig. 52.

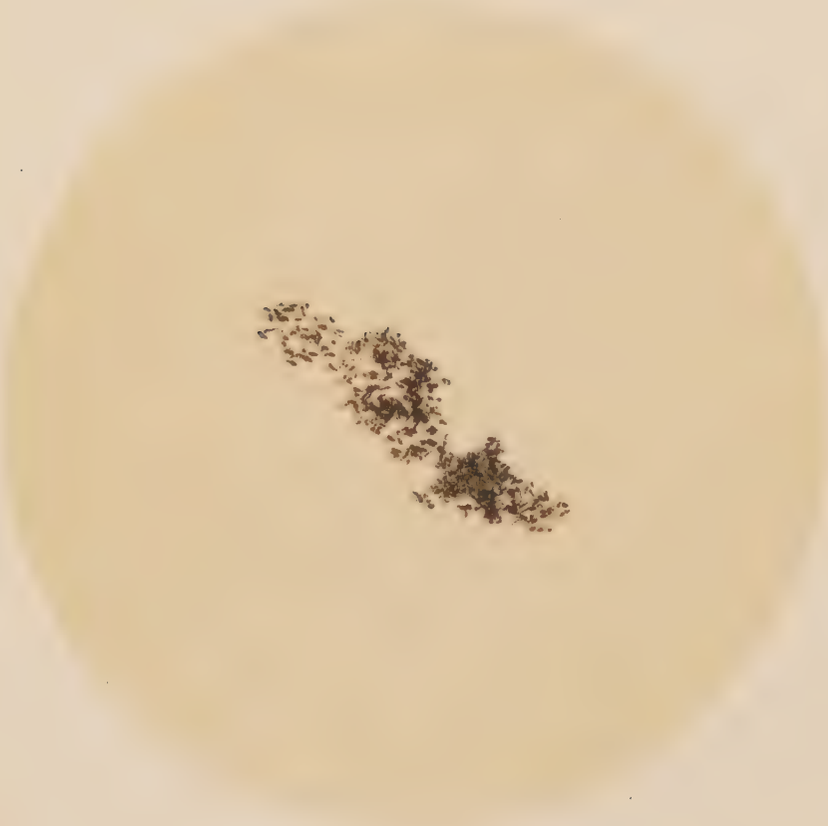

Fig. 53.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXIII.

FIG. 52.

Reproduced from a photograph of the diphtheria bacillus from a *gelatine* culture derived from the necrotic tissue of the tumour locally induced in cow No. 1 by inoculation of bacillus diphtheriæ from a human source.

Magnifying power 1,000.

FIG. 53.

Reproduced from a photograph of a single colony of the diphtheria bacillus derived from a *gelatine* culture inoculated with milk from a sound teat of cow No. 2, five days subsequent to inoculation of that animal with bacillus diphtheriæ from a human source.

Under a lower power.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXIV.

FIG. 54.

Reproduced from a photograph of the colony referred to under fig. 53, more highly magnified. The club-shaped form of the diphtheria bacillus is here abundantly represented.

Magnifying power 700.

FIG. 55.

Reproduced from a photograph of the same colony still more highly magnified.

Manifying power 1,000.

Fig. 56.

Reproduced from a photograph of "filamentous" diphtheria bacilli observed in the necrotic tissue of the locally-induced tumour of cow No. 2.

Magnifying power 700.

[This lithograph fails altogether in depicting the filamentous character of the bacilli in question.]

Fig. 54.

Fig. 55.

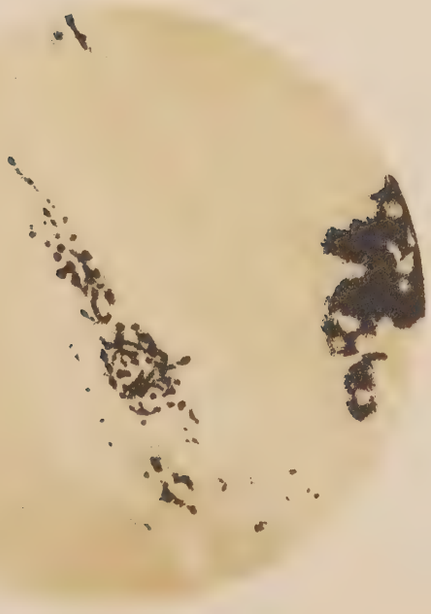

Fig. 57.

A. Pringle.

Fig. 57.

Fig. 58.

H. Lapidge.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXV.

FIG. 57.

Diphtheria bacilli from the *gelatine* culture referred to under figs. 53–55 as having been derived from the milk of cow No. 2. Club-shaped as also conical forms of the bacillus are abundant.

Magnifying power 700.

FIG. 58.

Represents a section, stained in methyl-blue and in rubin, though the locally induced subcutaneous tumour of cow No. 2, which is referred to also under figs. 48 and 49. Here masses of filamentous diphtheria bacilli (blue) are observed in and between the muscular fibres which are stained pink.

Magnifying power 200.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXVI.

FIGS. 59 and 60.

Represent each a muscular fibre from the section of tumour referred to under fig. 58. Fig. 59 is a fibre from near the upper edge of the specimen; fig. 60 a fibre from the left upper corner. The filamentous nature, with intercalated granules, of the diphtheria bacilli is well shown in these figures.

Magnifying power 1,000.

Fig. 59

Fig. 60.

M. H. Lapidge.

Rē & Doc.ors' Commons

Fig 61.

Fig. 62.

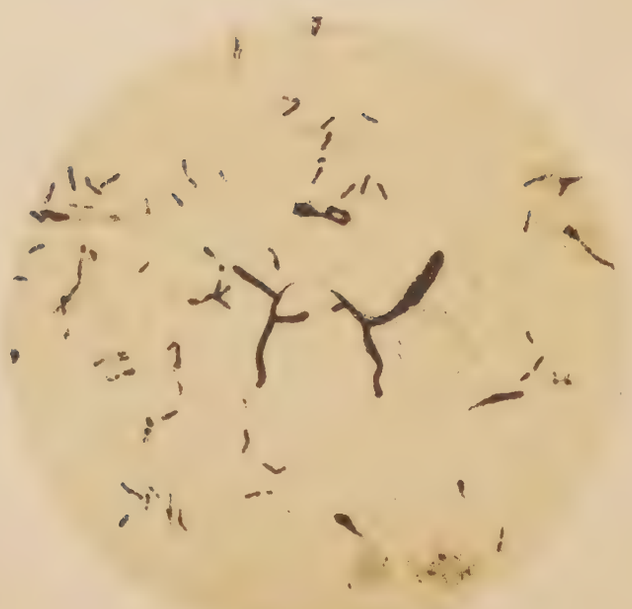

Fig. 63.

## ETIOLOGY OF DIPHTHERIA.

(Comparative.)

### PLATE XXVII.

FIGS. 61, 62, and 63.

Reproduced from photographs of specimens from culture on *Agar Glycerine* of the TUBERCLE BACILLUS. Specimen 61 was from a culture several weeks; specimens 62 and 63 from cultures several months old. In specimen 61 besides typical tubercle bacilli there were seen some that were club shaped. In Specimens 62 and 63 some of the tubercle bacilli had become branched and filamentous, with club-shaped branchlets.

Magnifying power 1,000.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXVIII.

FIG. 64.

Represents the condition of a portion of the udder of cow No. 2 on the *eighth day* after inoculation into the subcutaneous tissue of her shoulder of diphtheria bacillus from a human source. There were here observed several small raised red papules, three large and one small vesicle, and several dark coloured scabs. The scabs had been two days previously pustules.

Natural size.

[The vesicles are wrongly represented as yellow in colour.]

Fig. 64.

M. H. Lapidge

Fig. 65.

M.H.Lapidge

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXIX.

FIG. 65.

Represents another portion of the udder of the same cow (No. 2) on the *sixth day* after the inoculation referred under the previous figure. There were observed two vesicles and two scabs.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXX.

FIG. 66.

Represents, also on the sixth day after the shoulder inoculation, a portion of the udder of cow No. 2, different from those depicted in figs. 64 and 65.

Both vesicles and scabs are again represented.

Natural size.

Fig 66

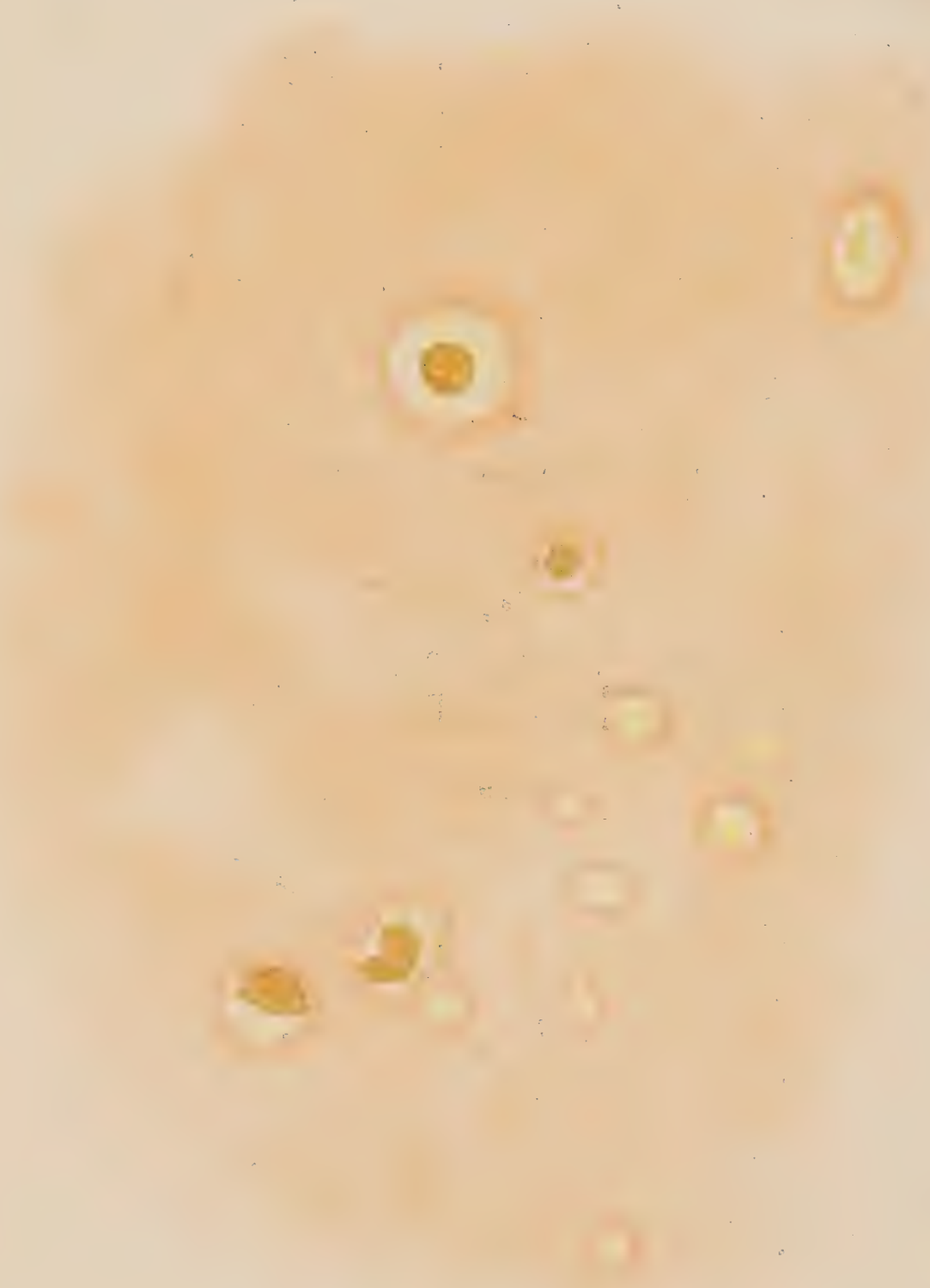

Fig. 67.

M.H. Lapidge

Judd & Co Lith. 7 & 7 Farringdon Rd & Duke Street Com

# ETIOLOGY OF DIPHTHERIA.

## PLATE XXXI.

FIG. 67.

Represents numerous vesicles at the sites of incisions in the skin of the belly of a calf (No. 1), which incisions had been about 11 *days* previously inoculated with material from the vesicles and pustules on the udder of cow No. 2.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXII.

FIG. 68.

Represents the superficies of the *lung* of cow No. 1 that died in consequence of inoculation into her subcutaneous tissue of the diphtheria bacillus from a human source. The lobules are seen to be intensely congested, a portion (to the left of the drawing) of the lung almost hepatised. The pleural lymphatics are well displayed as a network of vessels filled with clear lymph.

Natural size.

Fig. 68.

Fig 69

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXIII.

FIG. 69.

Represents the pleural surface of the *lung* of Cow No. 2. The interlobular septa were œdematous and thickened, and the lobules much congested. The pleural lymphatics were well marked as a dense network of vessels filled with sanguineous fluid.

Natural size.

[This lithograph fails to bring out the points of the original drawing, especially in the matter of the network of pink lymphatic vessels.]

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXIV.

FIG. 70.

Represents a portion of the *spleen* of cow No. 1. The buff-coloured streaks and patches correspond to thickenings of the capsule.

Natural size.

Fig. 70.

M. H. Lapidge.

Judd & Co. Lith. 73 & 75, Farringdon Rd & Doctors Commons.

Fig. 71.

M. H. Lapidge.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXV.

FIG. 71.

Represents the surface of the *liver* of cow No. 1. The several brownish patches correspond to necrotic hæmorrhagic masses of liver tissue.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXVI.

FIG. 72.

Represents the external surface of the *heart* of cow No. 1, and shows numerous petechiæ.

Natural size.

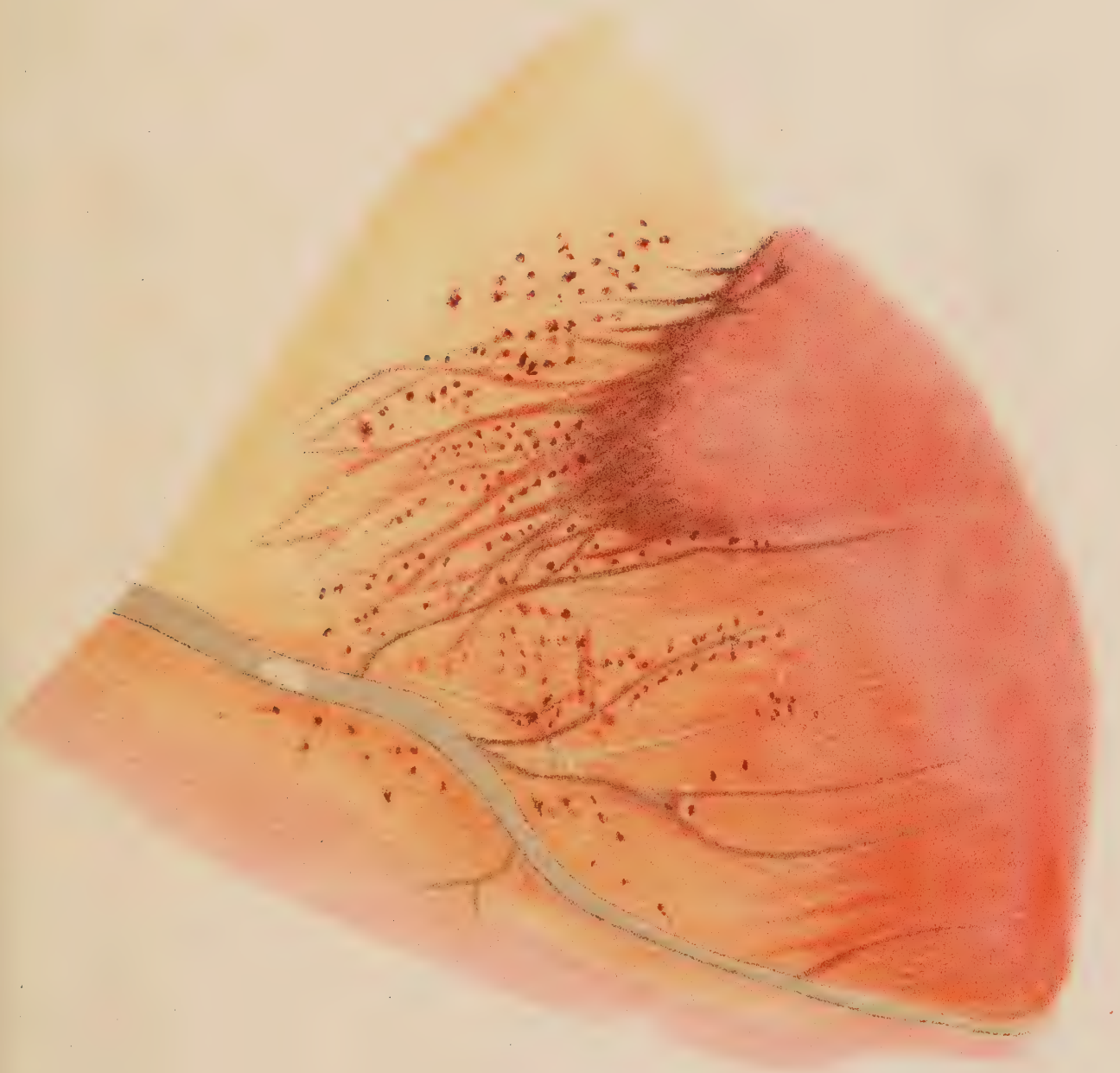

Fig. 72

M. H. Landsberg

Fig. 73.

M.H.Lapidge.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXVII.

FIG. 73.

Represents a portion of the upper lobe of the *lung* of calf No. 1, referred to under fig. 67. A part of this lobe was, it will be observed, in a condition of hepatization.

Natural size.

## ETIOLOGY OF DIPHTHERIA.

### PLATE XXXVIII.

FIGS. 74 and 75.

Represents sections of the *kidney* of calf No. 1, referred to under figs. 67 and 73. The cortex of this kidney is observed to be distinctly fattily degenerated.

Natural size.

Fig. 74.

Fig. 75.

## No. 2.

## On Concurrent Inoculation of Different Infections in the same Animal Body; by Dr. Klein, F.R.S.

On Concurrent Inoculation of Different Infections in the same Animal Body; by Dr. Klein.

There are various observations on record, based on direct and systematic experiments, tending to indicate that certain bacteria are antagonistic one to another; so that outside as also within the animal body, the life processes of a given species may become neutralised, or at least interfered with by the life processes of another and different species.

Experiments of previous observers:

Garré (Ueber Antagonisten unter den Bacterien, Correspondenzbl. f. Schweizer. Aerzte XVII. 1887) states that nutrient gelatine which has been made to serve for culture of the common putrefactive bacillus fluorescens putidus (an organism not liquefying this medium) becomes thereafter incapable of serving as nutritive pabulum for particular organisms, namely,—staphylococcus pyogenes aureus, the typhoid bacillus, the capsulated bacillus of Friedländer, and the common pink torula. And that on the other hand such gelatine remains still nutritive for certain other bacteria, as for instance for the cholera comma bacillus, which grows on it, though tardily; and for Finkler's comma bacillus and bacillus anthracis, which grow luxuriantly and normally on such gelatine. Further, Garré ascertained that inhibitive function of this sort is not necessarily a mutual one; for he found that while bacillus fluorescens putidus and the typhoid bacillus are in the above sense mutually antagonistic, this is not the case with the staphylococcus pyogenes aureus and Friedländer's pneumonia bacillus. Thus,—though gelatine on which the bacillus fluorescens putidus has been growing becomes non-nutritive for the two last-named microbes, the reverse does not hold good; for gelatine in which either of these two species has been grown, still remains nutritive to the bacillus fluorescens putidus.

Garré.

Soyka and Bandler (Fortschritte der Med. 1888, p. 769) instituted similar experiments, and their results are very important, since their observations extended to a considerable number of pathogenic microbes. They found that:—

Soyka and Bandler.

(1.) The cholera comma bacillus grew well on gelatine exhausted by,—*i.e.*, on which there had been previously grown,—one or other of the following microbes:—micrococcus tetragonus, Friedländer's bacillus, and bacillus of swine erysipelas.

(2.) Finkler's comma bacillus grew well on gelatine whether "exhausted" by Emmerich's bacterium, streptococcus of erysipelas, bacillus of septicæmia of the rabbit, micrococcus tetragonus, pneumococcus, typhoid bacillus, or by the swine erysipelas organism.

(3.) Bacillus anthracis and bacillus pyocyaneus grew well on gelatine "exhausted" by either the micrococcus of erysipelas, the septicæmia microbe of the rabbit, micrococcus tetragonus, pneumococcus, the swine erysipelas organism, or the typhoid bacillus.

(4.) Bacillus prodigiosus grew well on gelatine "exhausted" by either Emmerich's bacterium, the microbe of rabbit's septicæmia, micrococcus tetragonus, staphylococcus flavus, or bacillus cyanogenes.

I have next to note experiments of another class, and of fundamental importance, since they test *within the animal body*, in the matter of

their inhibitive function, certain pathogenic bacteria including the streptococcus of erysipelas. The demand for such experiment must be obvious from the fact that if an antagonism of this sort can be proved to exist between pathogenic species, such antagonism may perhaps be utilised for prophylactic and for curative purposes. And not only is there need for knowledge on the above point, but need also for information in a converse direction. For as I shall presently show, there exist micro-organisms which by their occupancy of, and life processes in, a given soil, exalt the nutrient properties of such soil as regards other and later arriving organisms; and with the result of enhancing the virulence of such later comers as are pathogenic. Obviously therefore it is of especial importance, as regards the several pathogenic species, to accurately determine experimentally which are inhibitive of, and which are overcome by, other organisms; and similarly to inquire which are mutually inhibitive and which mutually intensifying.

Emmerich.

Emmerich experimented with the bacillus anthracis and the streptococcus of erysipelas as follows :—By inoculating simultaneously into the same rabbit pure cultures of both organisms, and by in other cases injecting the streptococcus of erysipelas before or after inoculation of bacillus anthracis, he sought to ascertain whether and to what extent the pathogenic action of the bacillus anthracis was interfered with by his procedures. Thirty rabbits were accordingly inoculated with culture of bacillus anthracis, the number of bacilli introduced being in all cases about the same, as was determined by plate culture. Fifteen of these animals had been, previously (2–14 days) to their anthrax infection, inoculated with culture of streptococcus of erysipelas, whereas other fifteen were not prepared by previous injection of the streptococcus erysipelas. All of the latter succumbed to normal anthrax within 2–5 days of their inoculation therewith. But of the 15 previously prepared in the way above stated, 7 survived, the other 8 dying of anthrax or of erysipelas infection.

As regards injection of the erysipelas microbe subsequent to inoculation with anthrax material, this,—especially when the anthrax illness had already manifested itself,—was far less successful. Of 16 animals thus dealt with only 2 survived. Nevertheless, in these cases Emmerich noticed that the death of the animals by anthrax became distinctly delayed; and moreover that injection of the erysipelas microbe at the seat of the anthrax inoculation had a decided influence on development of the anthrax tumour. Particularly interesting is the following experiment of Emmerich :—Two rabbits (*a* and *b*) of the same litter were simultaneously inoculated with bacillus anthracis (about half a million bacilli being introduced into each animal). Eight hours and a half afterwards, Emmerich injected into the ear vein of rabbit (*a*), as also into the place where it had received its anthrax inoculation, a culture of streptococcus of erysipelas; rabbit (*b*) being at the same time left alone as a control experiment. The result was very striking :—rabbit (*b*) succumbed to anthrax after 70 hours, whereas rabbit (*a*) survived.

Microscopic examination in due course by Emmerich of the organs of those of his experimental animals in which injection of the erysipelas microbe had prevented development of fatal anthrax, showed in suitably stained (after Gram) preparations, that the anthrax bacilli were in a state of granular disintegration; that they were in fact dying or dead.

It is, however, necessary to add that other observers have not confirmed Emmerich's observation as to the victory obtained by the ery-

sipelas streptococcus over the bacillus of anthrax. Hereon Emmerich justly urges that for success of such experiment care must be taken not to introduce the anthrax bacillus in numbers at all largely in excess of the streptococcus of erysipelas.

In an altogether different direction are the observations of Achille Monti (Rend. d. R. Acad. dei Linæi. Ottobre 6, 1889). This observer proved by careful experiments that cultures of the diplococcus pneumoniæ which have lost,—through repeated subculture or by mere lapse of time,—their virulence for rodents, may easily be rendered once again virulent to such animals by simultaneously injecting into them, either separately or mixed together, such cultures of the diplococcus pneumoniæ and a sufficient quantity of the chemical products of the common saprophytic bacillus known as the proteus vulgaris. In this case injection of the chemical substances referred to may be thought of as modifying the constitution of the tissues in a way that prepares them to respond at once to the introduction of microbes against which they would otherwise have proved "refractory" or insusceptible.

Monti.

"Insusceptibility" of the tissues is, as is well known, considered by some authorities to be connected with, if not wholly dependent on, the chemical nature of the tissues: so that while the tissues are normal or in full vigour (if the phrase may be allowed for the purpose of illustrating my meaning), a particular microbe getting access to them fails to thrive there; cannot, so to speak, overcome the resistance, or inimical action, offered by the tissues. This power of resistance of tissues can, however, be greatly reduced or even abolished by certain means—such as depression of their vitality either due to ptomaines and certain other chemical substances which have invaded them, or to nervous exhaustion; and the like. Thus Bujwid (Centralbl. f. Bacteriologie) found that by antecedent injection into the subcutaneous tissue of an animal of a 12 p. c. sugar solution, experimental inoculation of staphylococcus pyogenes aureus was in most instances followed by suppuration; a result not easily achieved by means of this staphylococcus in the absence of previous sugar injection. H. Leo (Zeitschrift für. Hygiene, VII. 3), however, ascertained that the presence of much sugar in the blood and tissues does not increase susceptibility to anthrax or tubercle, though it does so in a conspicuous manner as regards glanders. He administered phloridzin in small doses along with food for some days previous to inoculation, with the result that sugar became present in the tissues of the experimental animal; and he found two rats thus prepared no more susceptible to anthrax than unprepared rats, and that mice and guinea-pigs similarly saccharised before they were inoculated with tubercle, showed no increased susceptibility to that infection. On the other hand white mice, which are normally but little susceptible to glanders infection, became highly susceptible of it if previously dosed with phloridzin. Charrin and Roger too (La Semaine méd. 1890 N. 4) show that normal rats, which as is well known are very little susceptible to anthrax, become susceptible to this disease in a marked degree if they are, when caged, made to work a treadmill, so as to become thoroughly fatigued.

Tissue susceptibility and insusceptibility

Other observers.

All these observations are in complete accord with the views of many observers as to the increased susceptibility of the human subject to one and another infectious malady under conditions which have depressed the bodily or mental powers.

I proceed now to report on two series of experiments recently undertaken by me. One has had reference to the behaviour, antagonistic or otherwise, within the animal body of different species (two in each experiment) of microbes simultaneously inoculated there. The other has tested the practicability of increasing by injection of certain

Present Experiments.

chemical substances, the susceptibility of a given animal towards a particular microbe.

## Series I.—Simultaneous Inoculation of Animals with different Species of Microbes.

New Experiments.

(*a.*) *Bacillus of swine fever and bacillus of fowl enteritis.*—These, though belonging to the group of pathogenic microbes, do not both of them act pathogenically on the same species of animal.

With swine fever and fowl enteritis.

*The bacillus of swine fever* produces in *mice* general septicæmic infection, causing death in a period varying from 3 to 6 days, or even a little longer, after inoculation. *Post-mortem.*—In the *heart's blood*, in the *spleen*, *kidney*, and other *viscera* the micro-organism in question is found in large numbers, as can be easily demonstrated by means of coverglass specimens, in microscopic sections, and by culture. A droplet of heart's blood or a minute particle of spleen tissue, yields on gelatine culture large numbers of the characteristic colonies of this bacillus. The microbe grows and multiplies at 36–37° C. with great rapidity ; in 24–48 hours it renders broth strongly and uniformly turbid.

*The bacillus of fowl enteritis*, described by me last year (the Field, and Centralbl. f. Bacteriol. 1889) is an organism which grows as rapidly as the microbe of swine fever. But mice are with difficulty infected by it, and rarely die as a result of its inoculation.

For the purpose of testing whether any and what antagonism of these organisms occurs within the body of the *mouse*, a number of these animals were simultaneously inoculated with samples of both species. Pure broth cultures of each organism, 24 hours old, and uniformly turbid, were mixed in equal quantities, and of this mixture 2 to 3 minims were injected under the skin of the back of each mouse. Coincidently with injection of the mice investigation was made by plate cultivation of the relative proportions of the two species in their respective broths, with the result of finding that they were equally abundant each in its own culture fluid; that is to say, both grew well in the same kind of broth, and that when kept in all respects under the same conditions (incubated at 36–37° C.) they multiplied with about the same rapidity. The result of the above inoculations was that all the mice died of swine fever in the usual time. From their heart's blood (after death), and from the spleen only, were colonies of the swine fever microbe recovered. But they were obtained in very large numbers, as if indeed the swine fever microbe had alone been injected. This experiment was repeated several times, and the result was always the same. The bacillus of fowl enteritis introduced simultaneously with the swine fever bacillus would seem therefore to fail altogether in neutralising the pathogenic action on the latter; the mice succumb in the usual time and in the usual way to the swine fever infection, while from their blood and tissues the swine fever organism alone can be recovered.

With swine erysipelas and swine fever;

(*b.*) *Bacillus of swine erysipelas and bacillus of swine fever.*—1. Pure broth cultures, 3–4 days old, of the swine erysipelas bacillus and of the swine fever bacillus, were mixed in different proportions.

in different proportions,

Considerably more of the former culture was used, for the reason that the swine erysipelas bacillus grows much more slowly than the swine fever bacillus, so that in broth culture of equal age the latter organism is greatly more abundant than the former. Thus a broth culture of swine fever bacillus is strongly turbid after 3–4 days' incubation, at 36–37° C., whereas a broth culture of swine erysipelas is only very slightly turbid after lapse of a like period. The organism of swine erysipelas

inoculated into white mice causes death in those animals, usually within a couple of days. *P.M.*—All viscera are highly congested, and the blood in them, as also the heart's blood, contains the microbe in abundance. Of the above mixture of the pure broth cultures, 1–2 minims were injected under the skin of two mice. Both animals were quiet on the third day, and dead on the fifth day. Cultivations were then made from the heart's blood on gelatine. Curiously enough, only one of six tubes thus inoculated showed any growth at all; and this, which consisted of a single colony, was not the swine fever bacillus, but the bacillus of swine erysipelas. Had these animals died of swine fever the blood would have contained the swine fever bacillus in large numbers, and in the cultures therefrom colonies of this organism would have been very numerous. It is clear, then, that in these cases the animals did not die of swine fever, but of swine erysipelas. Now the quantity of swine fever bacilli used for inoculation in these cases was amply sufficient to insure infection in the ordinary way, as I know from many other experiments. Indeed production of fatal swine fever in mice, with recovery by culture from their blood of abundance of the microbe of swine fever, is a common-place experiment enough. But in these instances the swine fever bacilli inoculated were not found in the blood of the mice after death, and there can apparently be no question that those which had been experimentally introduced had been neutralised or killed off as the erysipelas bacillus gained supremacy and developed in the mice its own disease. So that we are justified in affirming that in this experiment, in which the swine erysipelas bacilli were introduced in larger proportion than swine fever bacilli, the development of the latter was prevented, and swine fever disease averted. Under the particular circumstances of the experiment, therefore, the erysipelas bacillus appears to have gained the victory over the swine fever bacillus.

in equal proportions.

2. I now mixed in equal proportions, material from broth cultures of swine erysipelas, and from broth culture of swine fever (separately grown as before), and with it I inoculated four mice. The swine erysipelas culture was slightly, that of swine fever very turbid One mouse died on the fourth day, one on the fifth, and the other two on the sixth day. Cultivations were made of their hearts' blood, and of their spleen tissue; and after a week's incubation of these cultures it was ascertained that in them the number of swine fever colonies were more than twice as numerous as colonies of the swine erysipelas organism (62 to 27). Here, then, in complete contrast with the previous experiment, the swine fever bacillus gained the ascendency, in that it proceeded in its processes altogether undisturbed by its antagonist. The duration of illness in the mice moreover was in no way prolonged; it was just that usual when the swine fever organism alone is injected into these animals.

3. I next distributed in a given quantity of sterile salt solution a small particle taken from a surface growth on gelatine of swine fever bacillus, and in a like quantity of the same solution I distributed a small particle of the surface growth on gelatine of bacillus of swine erysipelas. Then I mixed together equal parts of the prepared salt solutions, and with the mixture inoculated four mice; making at the same time plate cultivations of the mixture in order to ascertain the relative proportions of the two organisms. These were after a week's incubation ascertained to be in the ratio of 34 swine fever to 29 swine erysipelas. Of the four mice, one died on the fourth, two on the seventh, and the fourth on the eighth day. In these animals, therefore, death once more took place after an interval not differing from that observed when swine fever bacilli alone have been inoculated. Cultivations made from the heart's blood and the spleen tissue of these mice showed large numbers of colonies of both

swine fever bacilli and swine erysipelas bacilli; but the former were predominant in the proportion of five to two.

4. From a gelatine culture of the heart's blood of one of the mice mentioned under experiment 2, in which both of the above microbes had been growing together for three weeks, I made a salt mixture, and with this inoculated two mice. At the same time I made plate cultivations with a view to ascertaining the relative proportions of the two microbes in the mixture. These after a week's incubation were found to be eight swine fever to one swine erysipelas. One of the mice died on the third, the other on the fourth day. Cultivations made, in six gelatine tubes, with a trace of the heart's blood of the first mouse, resulted thus: Two tubes had each one colony of the swine erysipelas bacillus only, two tubes had each two colonies of the swine fever bacillus, and two tubes had each three colonies of the swine fever bacillus and two colonies of the swine erysipelas bacillus.

The result in this case showed no notable antagonism within the animal body between the two microbes after they had been growing together side by side for three weeks in the same culture medium.

Summary of results.

From these experiments we learn then, as regards the bacillus of swine fever and the bacillus of swine erysipelas, that there occurs no very obvious conflict between these organisms, whether they are grown together on gelatine or are simultaneously inoculated into mice. Thus, if the two organisms are injected into mice in about equal proportions, or even with the swine fever bacillus in excess, the result is that the experimental animals die, and that their blood and spleen contain both microbes in large numbers. Nevertheless it would appear that an inhibition of one over the other may be manifested when for inoculation of mice the swine erysipelas bacillus is used in numbers considerably in excess of the swine fever bacillus. Under the latter conditions the swine fever bacillus failed to multiply within the experimental animals to the usual extent, so that from the heart's blood no colonies of it could be obtained; but on the other hand the swine erysipelas bacillus also failed in this case to multiply itself at all largely, for only a single colony was recovered from a drop of the heart's blood of the experimental animals. It would seem, therefore, from this experiment, that the two organisms do now and again within the animal body exert a mutual inhibition of each other's multiplication.

## Series II. — Injection of Animals with certain Chemical Products of Bacterial Life concurrently with Inoculation of them with the Microbe of Erysipelas.

Experimental inoculation of erysipelas microbe alone;

Having, under circumstances which are the subject of a separate paper, obtained, by plate cultivation, colonies of the streptococcus of erysipelas, I proceeded to test it in the following manner:—

With cultivations in broth of this streptococcus (two days old) I inoculated *superficially* the skin of the ear of two *rabbits*. Next day there were obvious signs of success, the place of inoculation and its neighbourhood having become red and swollen. Forty-eight hours later this redness and swelling had considerably increased, but it had not extended beyond the root of the ear. At the end of three days the redness and swelling began to subside, and by the fifth day not much of them was left.

I next inoculated *subcutaneously*, from a broth culture of the organism, two *mice*. One mouse was found dead after 36 hours, the other after 50 hours. On *post-mortem* examination the *lungs* and *liver*

On Concurrent Inoculation of Different Infections in the same Animal Body; by Dr. Klein.

of the mice were much congested; the *spleen* was not enlarged. Cultivations from their heart's blood yielded no result; from the liver, however, a few colonies of the streptococcus were recovered.

Two *rabbits* were then inoculated *subcutaneously* into the groin with a few minims of a similar broth culture. They died after six days; and on *post mortem* there was found :—in the *pericardium* exudation; in the *lungs* hyperœmic patches; on the surface of the *liver* numerous grey dots, the margin on its right side being altogether grey. The *spleen* was not enlarged. From the heart's blood no colonies were recovered, but cultivations of the liver yielded positive results.

The above experiments were made during September, and further subculture of the streptococcus was carried on in gelatine tubes for several generations during October and November. At the later date, when they came to be tested on the skin of the rabbit's ear, and by subcutaneous injection into the groins of the rabbits and mice, they were found to produce no result whatever; in no case was either local or general effect produced. Hereupon, with assistance by Dr. Schorstein, who was just then working in my laboratory, I determined to attempt—after the method adopted by Achille Monti with reference to "attenuated" pneumococcus,—restoration of the pathogenicity of our erysipelas streptococcus, namely, by injecting it into animals simultaneously with broth that had served for growth of the proteus vulgaris already referred to. Accordingly, broth culture was newly made of my attenuated streptococcus of erysipelas, and broth culture also of proteus vulgaris. After incubating for 48 hours the proteus culture was heated to 70° C., and kept at that temperature for five minutes, with the result that the broth became completely sterilised,—inoculations of fresh culture material from such broth remaining quite barren of growth. Having done this, we inoculated rabbits subcutaneously with my attenuated streptococcus culture, and also with the sterilised proteus culture; these inoculations being made simultaneously at different points in the same rabbit, or a mixture in equal proportion of both sorts of material was injected at a given spot. [With reference to these procedures it needs to be noted incidentally that we found it a matter of indifference whether the two sorts of material are separately injected or whether they are injected as one mixture. And further we ascertained that it is altogether indifferent whether the proteus broth culture be or be not sterilised before injection. For injection of a non-sterilised proteus broth culture containing the organism in living condition (practised by us as a control experiment), produces in the rabbit no effect whatever when administered in the quantities we adopted, namely, the half to the whole contents of a Pravaz syringe.]

and in conjunction with chemical products of proteus vulgaris.

Results.

The result that we obtained in the rabbit by injecting broth culture of the attenuated streptococcus of erysipelas (which when by itself injected into control rabbits produced no result whatever) simultaneously with broth culture of proteus in the amount above indicated, was very striking and positive. The animals succumbed to general infection in from one to three days. Cultivations, made after death of such animals, from the heart's blood afforded, it is true, no colonies of the streptococcus; but from the tissue of the liver, which contained many greyish white specks, numerous colonies of the erysipelas streptococcus were obtained on gelatine. Thus, by concurrent injection of the attenuated organism and of chemical products of the proteus, (a microbe in itself harmless,) we have restored the virulence of a streptococcus which under subculture had lost altogether its pathogenicity. Similarly, by this method of dealing with it, the specific action of this streptococcus on the skin of the rabbit's ear becomes at once fully restored, and produces results as

distinct as when it was first obtained by me. At no time, however, was its action in this sense so pronounced as is sometimes that of the streptococcus of Fehleisen; its effect was, as has been said, slighter and unaccompanied by those extensive swellings and congestions which occasionally spread from the ear to the neck in rabbits inoculated with Fehleisen's streptococcus. Nevertheless, there can be no doubt that as in the instance of the pneumococcus mentioned by Achille Monti so also in the case of this streptococcus of erysipelas, lost virulence has been re-established when the chemical products of a common saprophyte like the proteus vulgaris are simultaneously introduced into the experimental animal.

Other considerations that are involved.

The facts above recorded may have, it needs hardly be said, an important bearing on the seeming different predisposition of different individuals to the same infectious disorder, and on the observed greater virulence of particular pathogenic infections in one person as compared with another. No doubt the number of microbes constituting a given (and single) infective dose may (and in the case of some organised infections, do) influence the duration of the incubation period, as also the severity, of the resulting illness. But there remain instances where, notwithstanding that the conditions of infection—quantity of dose, virulence of infective matter, and the like—have appeared to be identical, the results on the individuals actually becoming infected have been very diverse; so that while one person is attacked after a long interval and slightly, his companion is attacked quickly and severely. Such differences are very difficult of explanation, and it may well be that among the conditions which have conduced to discrepancy of result of the above sort, the presence or absence in a person,—on the occasion of his receiving his infection,—of some substance of recent bacterial outcome, may have had considerable influence.

In bringing this paper to a conclusion, I would wish to mention a preliminary experiment that I have made in the direction of concurrent introduction into the calf of vaccine and erysipelas.

Cultivations of the above streptococcus of erysipelas, soon after I had received it and while it retained its virulence, were used for the inoculation of calves concurrently with introduction of vaccine into their bodies in customary fashion. In each of two calves, calf lymph was introduced as usual into about 40 incisions of the cutis of the groin and abdomen. Immediately thereafter broth culture of the streptococcus of erysipelas was freely applied to the same incisions. The result *quâ* the erysipelas was entirely negative; only the vaccinia took, most incisions developing into the normal vesicles. In none of the incisions, whether they became vesicular or not, was there any appearance of action that could be referred to the streptococcus of erysipelas.

Similar experiment will have to be repeated after it has been first ascertained, by inoculation of a calf solely with erysipelas matter taken directly from human erysipelas, whether this animal is susceptible of erysipelatous disease. At present it is by no means certain that such is the case.

No. 3.

"Food-poisoning:"—Report on Bacteriological Investigation of certain Samples of Pork and Gravy-Stock from Carlisle; by Dr. Klein, F.R.S.



On 26th November 1889, I received from the Medical Officer of the Local Government Board, samples of pork and of gravy-stock with instructions to make experiment as to deleterious properties that might be possessed by them.

The pork in question was part of a pig or pigs which, whether eaten as pork or consumed in the form of pork-pies, had seemed to be closely associated, in the early days of November, with attack by diarrhœa of a number of persons in Carlisle and elsewhere who had partaken of it. The gravy stock had been in use for pork-pie making at the establishment whence was derived the pork above referred to. It could not, however, be affirmed that the stock which furnished the samples for experiment was necessarily the same with that which had been in use for the particular pork-pies which had seemed to cause diarrhœa in the persons consuming them. As regards the persons attacked, there was very generally an interval of not less than 24 hours between the occasion of eating the implicated food and the onset of illness.

With these materials I proceeded to experiment as follows:—

(1.) *Feeding Experiments.*

(*a.*) With *gravy-stock*, mixed with bread, three mice were fed. On the second and third days all these animals showed roughness of their coats; they were quiet, and did not move about. On the fourth day one was found dead. The other two were now very ill; one of them was found dead the next day, the other recovered.

(*b.*) Two additional mice were similarly fed with *gravy-stock* mixed with bread. One of them was found dead on the seventh day; the other was ill, but recovered.

(*c.*) With pieces of *pork*, six mice were fed. All six were ill on the second and third days. One died on the sixth day. By the seventh day the five remaining mice all suffered from bad diarrhœa, with fluid sanguineous evacuations. On this (seventh) day a second mouse died, and on the following day (the diarrhœa meanwhile continuing) two more mice died. The fifth mouse died on the tenth day, and the sixth and remaining mouse on the twenty-third day. All these mice presented *post-mortem* identical appearances:—The whole of the small *intestine* was relaxed and congested, and its cavity was filled with sanguineous mucus. Both *lungs* were deeply congested, and in the mice that survived longest there was hepatisation chiefly in the upper lobes. The *liver* was congested; in one animal only (a mouse dying on the sixth day after feeding with the pork) were there present numerous whitish grey specks in that organ. The *spleen* was congested in all; in a few cases only was it in addition very slightly enlarged.

Gelatine cultures inoculated with juice from the diseased lung, afforded in the case of every one of these mice an organism which proved to be a minute motile bacillus. From the limited number of colonies obtained in each instance, the organism could not have been abundantly present in the lungs of the experimental animals; and from their hearts' blood no colonies were obtained.

(2.) *Observation of the Bacillus obtained from the Lungs of the Experimental Mice.*

The bacillus in question is motile in few individuals only. Its thickness is about 0·4 m.m., in length it varies from that of a slightly oval coccus to cylindrical rods and to threads 2–3 m.m. in length. Thus, in gelatine culture several days to a fortnight old, there are found numerous threads of various length, some distinctly made up of a series of cylindrical rods, others smooth and uniform. Some of the threads are twisted and curled so that those composed of a series of rods resemble vibrios or even spirilla. I have convinced myself that these threads and long chains belong to identically the same species as the coccus and rodshaped forms, and in the following way:—Numerous plate cultivations were made in which it was always found that the colonies were all of them of exactly the same kind, and in these cultures as growth proceeded for a few days, the short bacilli were observed to grow out into the long forms. This bacillus though belonging to the group of polymorphous microbes is not, however, a member of the proteus group of Hauser; its manner of growth in the colonies is altogether different. The colonies of this bacillus remain limited to the spot where they first appear; though the colonies enlarge considerably in breadth, there is never any "swarming out,"—that is, no threads or strands are formed by which the colony spreads abroad so as to cover large areas of the gelatine as is the case with members of Hauser's proteus group.

On the *surface of gelatine* the colonies make their appearance about 24–36 hours after inoculation, as whitish-grey spots which enlarge during the next two or three days to the size of 1–2 m.m. The outline of the colonies is angular and they are prominent and thick, thicker in the middle than at the margin. In transmitted light they appear dark brown, in reflected light white with the faintest pinkish tint. On the fifth day, and at 20° C., the first indication of liquefaction of the gelatine is noticed. Liquefaction proceeds only very slowly, and the liquefied gelatine is clear and of the consistency of thick treacle. Later on the liquefied gelatine assumes a dark golden brown tint.

In *streak* cultivation the bacillus grows rapidly into a thick prominent band with knobbed crenate outline, the centre of the band being thicker than the margin. In reflected light the band is white though with some trace of a pinkish tint.

The bacillus grows well also on *Agar* and in *broth;* on the former as a pasty thick pellicle, in the latter it produces uniform turbidity with copious powdery floccular precipitate.

(3.) *Experiment on Animals with Culture of the Bacillus.*

Some mice were fed and others were at the same time inoculated with small amounts of culture of the bacillus on gelatine.

(*a.*) Two mice were *fed* with culture from the lung of a mouse that had died after experimental feeding with the pork. One of the above mice was found very ill on the fourth day; it could not move, its coat was rough, its eyes closed. It died at the end of the fourth day. The *post-mortem* appearances in this case were identical with those of the mice which died after feeding with the pork, namely: both *lungs* much congested; the *intestines* relaxed and containing sanguineous mucus; the *liver* full of minute grey spots; the *spleen* not enlarged. From the lung juice of this mouse cultivations were made and numerous colonies were obtained of the same bacillus as had been used for feeding

the animal. Similarly in cover glass specimens of its fresh lung juice numerous examples of the bacilli could be demonstrated. The heart's blood also of this mouse contained the bacilli as was demonstrated in cover glass specimens and by culture on gelatine.

The other mouse was also ill on the third and fourth days but by the fifth day had become livelier. On the sixth day it began feeding again, and by the end of the week seemed all right.

(*b.*) Two mice were *inoculated* under the skin of back with a trace of a gelatine culture (mixed with sterile salt solution). Both animals were found ill on the third day. One was found dead on the fourth day; the other remained ill (it was unwilling to move, refused food and had a rough coat) for several days but recovered.

The *post-mortem* examination of the mouse that died showed: intense congestion of *lungs*, the upper lobes hepatised and almost purple black in colour; the small *intestine* congested, relaxed, and filled with sanguineous mucus; the *liver* congested; the *spleen* not enlarged. Cultivations on gelatine having been made of the heart's blood and of the juice of the congested lung, colonies of the bacillus were obtained in great number. Similarly the bacillus was demonstrable in stained cover glass specimens of the fresh heart's blood and of the lung juice.

(*c.*) The above experiments (a. and b.) were now repeated. Two mice were *fed* with gelatine culture from the lung, at the same time that other two mice were *inoculated* under the skin with like material. The result was the same as before: All four mice became ill, and two of them died, on the fourth and fifth days respectively. That which died earliest had been fed, the other had been inoculated with the material of experiment. Both of the mice which were fed, and one of those which were inoculated had on the third and fourth days diarrhœa with fluid sanguineous evacuations. The *post-mortem* examination of the mice which died showed the small *intestine* much congested, relaxed, and filled with sanguineous mucus; both *lungs* extremely congested, some lobes almost purple black; the *spleen* not enlarged. From both mice, and alike from their inflamed lung and from their heart's blood, the bacillus of experiment was recoverable, as was demonstrated in cover glass specimens and by culture on gelatine.

From these experiments it appears that:—

1. The stock-gravy and the pork were alike capable of producing illness and death in mice fed with these materials.
2. The illness and death thus produced could hardly have been due to a chemical poison, for the induced disease did not set in until the second day after experimental feeding; there was, in fact, a definite incubation period of not less than 24 hours in all cases.
3. The symptoms noticed during illness, and the appearances observed after death, indicated severe intestinal disturbance and congestion of the lungs.
4. In the congested lung were present numerous bacilli of a single species that had definite cultural characteristics.
5. The bacillus thus obtained when introduced, whether by feeding or by inoculation, into other mice, produced in them illness and death,—with the same symptoms and pathological appearances as had been observed in mice fed directly with the pork or with the gravy-stock under suspicion. And further, from the bodies of the mice dead after feeding or inoculation with cultures of the bacillus, that organism was recoverable in abundance by appropriate methods.

To sum up:—We have then to do here with a true infectious disease producible in the first instance by feeding animals with given samples of gravy-stock and of pork, and capable of being propagated by a particular microbe isolable in artificial culture from the bodies of the rodents fed with the samples. The microbe here described is not the same as that described by me 10 years ago in connexion with the Welbeck and Nottingham meat poisoning; nor is it identical with either of those to which veal and pork pie poisoning has been referred by me in recent reports to the Medical Officer. It is an altogether different species, as will be clear from my account of its morphological and cultural characters.

Having regard to the very definite cultural characters of this microbe (especially to its pinkish white aspect, and its very slow liquefaction of the gelatine), I attempted to isolate it also from the gravy-stock. I was not particularly hopeful of success, because on making a preliminary examination of fresh specimens of the stock as dried and stained cover glass specimens, and as well by plate culture, I found the material to be swarming with numbers of different bacterial species, namely, various species of cocci, and bacilli, motile and non-motile, long and short, thick and thin. The gravy-stock had been sent in a stoppered wide-mouthed pint bottle, in which it had solidified. Accordingly my next step was to melt the material by placing the bottle in warm water; and this having been done the stopper was removed, and a drop or two of the fluid stock were transferred with a sterile capillary pipette to a tube containing a few c.c. sterile salt solution. With fluid stock thus diluted, several gelatine tubes were then inoculated by means of the platinum hook and the gelatine contained in them, used in the usual way for plate cultivation. In two plates out of six thus established, there appeared amongst colonies of other microbes, three colonies (in one plate two colonies, in the other one colony), which on examination by sub-culture proved to be the same microbe that had been recovered from the lung of the mice dead after feeding with the gravy-stock. Thus it was proved that the gravy-stock did actually contain the microbe which from the experiments and observations above described would appear to be the cause of this particular form of pork poisoning.

In the case of the pork I was less fortunate. By the time that I had come to know and was able to easily recognise this particular microbe, the pork had become all mouldy.

No. 4.





Further Report on Bacteria in their observed Relations with Digestive Processes; by Vincent D. Harris, M.D., F.R.C.P.

During the past year the experiments upon the above subject, commenced in 1888, have been continued.

Experiments have been made with anthrax spores and with certain other micro-organisms to be mentioned below, for the purpose of obtaining knowledge on the subject of the infection of the animal body through the channel of the intestinal canal.

The animals used for the experiments have been in all cases *white mice*, as particularly susceptible to anthrax; but for control experiments guinea-pigs and rabbits have also been made use of in several instances.

The plan of experiment has varied a little according to the micro-organism employed. The micro-organisms experimented with have been as follows:—

(*a.*) *The Spores of Anthrax.*
(*b.*) *Bacillus Prodigiosus.*
(*c.*) *Bacillus Tuberculosis.* (Koch.)
(*d.*) *Bacillus of Grouse Disease.* (Klein.)
(*e.*) *Bacillus of Typhoid Fever.* (Gaffky.)
(*f.*) *Bacillus of Pneumonia.* (Klein.)

### (*a.*) Experiments with Anthrax Spores.

Feeding experiments by previous observers.

A very considerable difference of opinion has existed and still appears to exist among authorities, as to whether an animal, when *fed* with anthrax material rich in spores, of necessity becomes infected by and dies of the disease. The experiments of Koch and his pupils Gaffky and Löffler, appeared to satisfy them that, when *sheep* are fed with anthrax material, the bacilli of anthrax are destroyed in the stomach, but that the spores of anthrax penetrate the mucous membrane of the intestine, and lead to a general infection. In their feeding experiments, when blood containing anthrax spores was mixed (after it had been dried for some time) in small quantity with sheep's food, the sheep remained unaffected. When the sheep were fed with fresh spores in similar quantity, the animals died, but rather later than usual (6–22 days). But when larger quantities of anthrax spores were administered with their food, death from anthrax resulted just as though the sheep had been directly inoculated with anthrax spores.

The experiments of these observers, however, with other animals, *e.g.*, rabbits, guinea-pigs, and mice, did not give constant results. This latter

experience coincided with some other and earlier experiments of Koch. In those earlier experiments of his (1877) Koch had administered to *mice*, material from sheep and rabbits that had died of anthrax, *e.g.*, the spleen of such animals as well as blood (wherein the anthrax bacilli had been allowed to form spores) which had been dried and powdered; and he found that the animals escaped infection. A similar series of experiments with *rabbits* gave similar results. From these experiments Koch drew the conclusion that mice and rabbits are not susceptible to anthrax when the material of that disease is introduced to their systems through the alimentary canal.

Pasteur, experimenting with *sheep*, added cultures of anthrax containing spores to their fodder, with the result of producing death from infection of the system through the intestinal canal in a certain number of cases; and he found that the proportion of successful experiments was much increased by adding to the fodder thistles and wheat-ears, or such other plants as would in all probability mechanically injure the mucous membrane of the mouth. Pasteur concluded, therefore, that infection, when it occurred, depended upon accidental inoculation through an abraded mucous membrane.

Toussaint, after a series of similar experiments, arrived at a like result. Buchner's experiments with *mice* showed that these animals, when fed with anthrax spores, did not in a great majority of cases succumb to the disease, although their fæces contained anthrax bacilli (or spores) which were capable of setting up anthrax in other animals.

On the other hand, Falk found that, although anthrax bacilli, when introduced into the intestine, do not penetrate the intestinal walls, yet when animals are fed with anthrax spores, a general infection is the invariable result. Flügge also follows on the same side, and asserts that the bacilli as such are unable to pass through an injured mucous membrane, but that anthrax spores can do so. Baumgarten goes a considerable step further; he believes that a number of micro-organisms *free from spores* can penetrate the healthy intestine, especially the bacilli of anthrax. His further conclusion seems certainly paradoxical, viz., that certain animals are susceptible to particular infection if it be prescribed to them in one way, but not susceptible to it if presented to them in another way. For example, that *cattle* are less susceptible to inoculated anthrax than some other animals, but that they are specially prone to become infected by means of food containing anthrax spores; and that the reverse is the case with *mice*, *rabbits*, and *guinea-pigs*, which are very susceptible to anthrax by inoculation, but are scarcely ever infected with it by means of feeding experiments.

[With regard to the more general question of the method of infection through the alimentary canal, Orloff, experimenting with the staphylococcus pyogenes aureus, came to the definite conclusion that the epithelium of the digestive tract protects the animal from infection through that channel, and that if infection takes place after feeding, an actual solution of continuity of the intestinal mucous membrane must have been present.

Korkanoff undertook very laborious and thorough researches upon *rabbits*, *white mice*, and *guinea-pigs*, administering to them in very large amounts, several species of micro-organisms, viz., Emmerich's Neapolitan bacilli, anthrax, and chicken cholera bacteria. With the single exception that rabbits fed with chicken cholera bacilli habitually perished, he obtained no constant results. And he came to the conclusion that only those micro-organisms which are able to produce a preliminary necrosis of the intestinal epithelium can cause a general infection. This property, he supposed, is possessed by the bacteria

of chicken cholera, but is not possessed by the Neapolitan bacilli of Emmerich, nor (so far as guinea-pigs and white mice are concerned) by anthrax bacilli and their spores. Nor is it possessed by the staphylococcus aureus (Orloff), bacillus indicus, the spores of bacillus subtilis, or by staphylococcus aureus (Wyssokowitsch)].

It will be seen from the above cursory sketch of the experimental researches which have been hitherto made upon this subject, that many authorities deny, whilst others assert, the possibility of the penetration through the healthy intestinal mucous membrane of anthrax spores, or of bacilli developed from them within the intestine.

Discordant conclusions

The following experiments had the double purpose of testing the action of the anthrax on the experimental animal, and the action of the latter's digestive apparatus on the anthrax. Their results go to support those who assert that, as far as *white mice* are concerned, infection with anthrax spores administered with their food seldom, if ever, takes place through the healthy intestinal mucous membrane.

Fresh Experiments.

The plan of experiment has been as follows :—After a fasting period of 12 to 24 hours, a pair of mice (in each experiment) were fed with bread sopped in distilled water, with which cultures of anthrax upon Agar-Agar, four days old at least (usually about a week old), had been thoroughly rubbed up with a glass rod. In order to eliminate the possibility of failure from the administration of too small a quantity of spores, abundance of culture material was used; as a rule, each animal took the contents of one culture tube at least. The animals readily eat the sopped bread. In two cases the spores were given as potato cultures, and in two other cases the culture was spread with a platinum hook *upon biscuit*, which the mice readily devoured. In one case the anthrax culture was given in milk. In order to test the virulence of the anthrax material (seen by the microscope to consist almost entirely of spores) in all the later experiments, control inoculations into mice were made. These control experiments (done with very small quantities of the anthrax material) showed that the animals so inoculated died, in due course, from anthrax. In order to test whether young animals, whose intestinal mucous membrane might be supposed to be less resistant than that of adult animals, were more susceptible than their seniors, three pairs of young mice were used, but not one died.

Anthrax.

*Table of Feeding Experiments with Anthrax Spores.*
(14 experiments, 26 mice.)

| Experiment No. | Antecedent Fasting. | Anthrax Material. | How given. | Result. | Remarks. |
|---|---|---|---|---|---|
| 1 (two mice). | 12 hours - | Agar Agar cultures. | With bread and distilled water. | Negative. | |
| 2 (two mice). | Do. - | Do. - | Do. - | Do. | |
| 3 (two mice). | Do. - | Do. - | Do. - | One mouse died of anthrax. | This mouse died in about 48 hours. |
| 4 (two mice). | 18 hours - | Do. - | Do. - | Negative. | |
| 5 (two mice). | Do. - | Do. - | Do. - | Do. - | Young mice. |

| Experiment No. | Antecedent Fasting. | Anthrax Material. | How given. | Result. | Remarks. |
|---|---|---|---|---|---|
| 6 (two mice). | 18 hours - | Agar-Agar cultures. | With bread and distilled water. | Negative - | Young mice. |
| 7 (two mice). | Do. - | Do. - | Do. - | Do. - | Do. |
| 8 (two mice). | Do. - | Do. - | Do. - | Do. | |
| 9 (two mice). | Do. - | Do. - | Do. - | Do. | |
| 10 (two mice). | Do. - | Do. - | Do. - | Do. | |
| 11 (two mice). | Do. - | Do. - | In milk - | Do. | |
| 12 (two mice). | Do. - | Potato culture. | - - - | Do. | |
| 13 (one mouse). | Do. - | Agar-Agar culture. | With bread - | Do. | |
| 14 (one mouse). | Do. - | Do. - | Do. - | Do. | |

In order to test whether the spores that had been administered were actually destroyed in the stomach, two additional mice having been fed in like manner with anthrax material, were killed one to two hours later, and cultivations were made from the contents of the alimentary canal. As a result the presence of anthrax was proved in both cases. This coincides with the already mentioned experience of Buchner.

It seems, however, that no hard-and-fast rule can be laid down at present as to the probability of infection of the system with anthrax through the healthy intestinal mucous membranes of mice.

### (*b.*) Experiments with the Bacillus Prodigiosus.

Bacillus prodigiosus.

This and succeeding experiments, had the single purpose of testing, on one and another micro-organism, the action of the digestive processes of the mouse.

The organism now in question, which is a colour-producing microbe, possesses the advantage of being easily recoverable from the experimental animal.

The plan of experiment with it was as follows:—Potato cultures of the organism, mixed with powdered biscuit and a little distilled water, were administered to *mice* which had fasted for a period varying from 12 to 24 hours. After a further interval, varying from one to two hours, the animals were killed with chloroform, and potato cultures were made of mucus obtained from different parts of their intestinal canal. The potatoes thus inoculated with the intestinal mucus were then kept in an incubator at a temperature of 20° C.

Twelve mice were experimented on, and with the result that in every case except one the bacillus was recovered from intestine, having escaped destruction in the stomach.

*Table of Experiments with Bacillus Prodigiosus.*

| No. of Mouse. | Antecedent Fasting. | Bacillus Culture; how given. | Mouse killed,—after Experimental Feeding. | Parts examined after Death. | Result of Culture of Specimens. |
|---|---|---|---|---|---|
| 1 | 12 hours | With biscuit powder. | 2 hours | Several parts of small intestine, chiefly ileum. | Rapid growth in all cases. |
| 2 | Do. | Do. | Do. | Large intestine | Do. |
| 3 | Do. | Do. | 2½ hours | Stomach | Do. |
| 4 | Do. | Do. | 2 hours | Small intestine | Negative. |
| 5 | 18 hours | Do. | 1 hour | Ileum | Rapid growth. |
| 6 | Do. | Do. | Do. | Duodenum | Do. |
| 7 | Do. | Do. | 2 hours | Middle of small intestine. | Do. |
| 8 | Do. | Do. | Do. | Ileum | Do. |
| 9 | Do. | Do. | 1¾ hours | Middle of small intestine. | Rapid growth in 24 hours. |
| 10 | Do. | Do. | Do. | Ileum | Do. |
| 11 | Do. | Do. | 2¾ hours | Middle of small intestine. | Rapid growth in 48 hours. |
| 12 | Do. | Do. | Do. | Ileum | Do. |

In connexion with these experiments, I tested the influence upon the bacillus prodigiosus of hydrochloric acid and of pepsin, as also the influence of a mixture of both substances. To this end a considerable amount of a potato culture of the organism was shaken up in a test tube and divided into portions A, B, and C, in separate test tubes. To A, pepsin to the extent of 0·8 per cent. was added; to B, hydrochloric acid 0·25 per cent.; and to C a mixture of pepsin and hydrochloric acid in like proportions. The tubes were kept at 40° C. for half an hour, and then from them potato cultures were made. Rapid growth took place in the case of A solution, indicating that pepsin alone did not affect the growth of this bacillus; but no growth occurred on potatoes inoculated from B and C. On careful neutralisation of the fluid of B, a culture upon potatoes was successful, but not so with C. This experiment would seem to suggest that the gastric juice as such would so change the organism as to render it incapable of growth; but this was not, as has been seen, found to be the case in actual experiment with the gastric juice of the mouse.

### (*c.*) Experiments with Bacillus of Tuberculosis.

Tubercle bacillus.

The question as to whether the beaded appearance of tubercle bacilli is really due to the presence in them of spores, as is held by

some observers, has suggested experiment for ascertaining whether these bacilli are destroyed in the stomach as are most sporeless bacilli; or whether they pass through the stomach unscathed. If they followed the latter and not the former course, it would seem to indicate that the beaded appearance of tubercle bacilli might be due to spores.

The following experiments go to show that morphologically at any rate the tubercle bacilli do not undergo change in passing through the stomach.

The plan of experiment was as follows:—Tubercular material,—either human tubercular lung which had been proved to contain considerable masses of bacilli, or pure cultivations of tubercle bacilli,—was administered to mice which had been kept fasting for about 18 hours; then, 1 to $2\frac{1}{2}$ hours after their experimental meal, the animals were killed and cover-glass specimens were made from the mucus in different parts of their intestine. These specimens were carefully stained in carbol-magenta solution, differentiated with 33 per cent. nitric acid, thoroughly washed in water, and then re-stained in methylen blue solution. Bacilli, which corresponded in appearance with tubercle bacilli, were found in every cover-glass specimen but one. In some mucus taken as a control experiment from the intestine of a fasting mouse, no tubercle bacilli were discoverable.

*Table of Experiments with Bacillus of Tuberculosis.*

| No. of Mouse. | Antecedent Fasting. | Tubercular Material. | | Mouse killed,—after Experimental Feeding. | Parts of intestine examined after Death. | Result of Culture of Specimens. |
|---|---|---|---|---|---|---|
| | | Source. | How given. | | | |
| 1 | 18 hours - | Tubercular lung. | With biscuit powder. | $1\frac{1}{2}$ hours - | Duodenum and Ileum. | Many tubercle bacilli in former; few in latter |
| 2 | Do. - | Do. - | Do. - | 2 „ - | Do. - | Few. |
| 3 | Do. - | Do. - | Do. - | 2 „ - | Mid-intestine | None. |
| 4 | Do. - | Do. - | Do. - | $2\frac{1}{2}$ „ - | Ileum - | Few. |
| 5 | 16–18 hours | Pure culture | Do. - | $1\frac{1}{4}$ „ - | Do. - | Very many. |
| 6 | Do. - | Do. - | Do. - | $1\frac{1}{2}$ „ - | Mid-intestine | Do. |
| 7 | Do. - | Do. - | Do. - | 2 „ - | Do. - | Do. |
| 8 | Do. - | Do. - | Do. - | $2\frac{1}{2}$ „ - | Do. - | Do. |
| 9 | Do. - | Do. - | Do. - | 1 „ - | Do. - | Do. |
| 10 | Do. - | Do. - | Do. - | $1\frac{1}{2}$ „ - | Do. - | Do. |

It remains to be determined, whether tubercle bacilli which have thus passed through the stomach of the mouse, still retain their power of producing tuberculosis when inoculated into rodents.

(*d.*) Experiments with the Bacilli of Grouse Disease. (Klein.)

Bacillus of grouse disease.

The plan of experiment with this micro-organism was very similar to the last, and to that described by me as having been pursued with anthrax bacilli in last year's series of experiments. Mice were fed with the micro-organism after having been kept fasting several hours. Some 1 to $1\frac{3}{4}$ hours later they were killed, and plate cultures were made from mucus obtained from their small intestines. In all, three experiments were made, and in two of them cultivations of the organism were obtained. In the third case a negative result could not be definitely affirmed.

*Table of Experiments with the Bacillus of Grouse Disease.* (Klein.)

| No. of Mouse. | Antecedent Fasting. | Material of Experiment given with | Mouse killed,—after Experimental Feeding. | Part of Intestine examined after Death. | Result of Culture of Specimens. |
|---|---|---|---|---|---|
| 1 | 18 hours | Biscuit - | 1 hour - - | Ileum - - | ? |
| 2 | Do. | Do. - | 1½ hours - | Do. - - | Growth of organism. |
| 3 | Do. | Do. - | 1¾ hours - | Do. - - | Do. |

(*e.*) Experiments with Bacillus of Typhoid Fever. (Gaffky.)

Gaffky's bacillus.

The vexed question as to the presence of spores in these micro-organisms might also be helped toward solution should the microbes be found to survive passage through the stomachs of mice; for as is well known, most recent observers deny the existence of spores in these bacilli. Accordingly, experiments have been carefully made, but so far with a negative result. The plan of the experiment was exactly similar to that already described. The material used was in all cases obtained from gelatine cultures.

*Table of Experiments with the Bacillus of Typhoid Fever.* (Gaffky.)

| No. of Mouse. | Antecedent Fasting. | Culture Material; how given. | Mouse killed,—after Experimental Feeding. | Parts of Intestine examined after Death. | Result of Culture of Specimens. |
|---|---|---|---|---|---|
| 1 | 15¾ hours. | With biscuit powder. | 1 hour - | Middle of small intestine. | Negative. |
| 2 | Do. | Do. - | Do. - | Lower part of small intestine. | Do. |
| 3 | Do. | Do. - | 1½ hours - | Middle of small intestine. | Do. |
| 4 | Do. | Do. - | Do. - | Upper part of small intestine. | Do. |
| 5 | Do. | Do. - | 2 hours. - | Middle of small intestine. | Do. |
| 6 | Do. | Do. - | Do. - | Lower part of small intestine. | Do. |

In not one of these experiments could undoubted cultures of Gaffky's organism be obtained upon the gelatine plates inoculated with mucus from the intestine. Micro-organisms, however, were present, which rapidly liquefied the gelatine; but these could not have been the typhoid bacillus, since one of its characteristic features is that it does not liquefy gelatine. I am aware, too, that Gaffky insists that a high temperature of 42° C. is necessary for spore formation in his bacilli.

(*f.*) Experiments with Bacillus of Pneumonia. (Klein.)

Bacillus pneumoniæ.

These experiments, six in number, have been carried out on the same plan as those with the bacilli of grouse disease and with the bacilli of typhoid fever. A considerable amount, in each instance, of gelatine-tube culture was administered to a mouse which had been kept fasting from

12–24 hours. From 1–2¼ hours subsequent to the experimental feeding the mice were killed, and gelatine-plate cultures were made with mucus obtained from different parts of their small intestines. These plates were placed in the incubator at 20° C.

*Table of Experiments with the Bacillus of Pneumonia.* (Klein.)

| No. of Mouse. | Antecedent Fasting. | Culture Material; how given. | Mouse killed,—after Experimental Feeding. | Part of Intestine examined after Death. | Result of Culture of Specimens. |
|---|---|---|---|---|---|
| 1 | 24 hours | With biscuit powder and distilled water. | 1 hour - | Ileum - - | Negative. |
| 2 | Do. | Do. - | 1½ ,, - | Jejunum - | Many growths. |
| 3 | Do. | Do. - | 2 ,, - | Do. - - | Do. |
| 4 | 12 hours | Do. - | 1¼ ,, - | Ileum - - | Do. |
| 5 | Do. | Do. - | 1¾ ,, - | Jejunum - | Do. |
| 6 | Do. | Do. - | 2¼ ,, - | Do. - - | Do. |

It will be seen as regards the experiments made so far with this micro-organism, that in the majority of cases it could be recovered from the intestines after having passed through the stomach.

## No. 5.

### Preliminary Report on the Chemical Products of the Life Processes of Bacillus Anthracis* ; by Sidney Martin, M.D.

*Object of the investigation.*—The objects of the investigation, the results of which are in part here recorded, were :—(1) to discover and isolate the chemical substances produced by the bacillus anthracis when grown in artificial cultures ; (2) to test the physiological action of these substances,—to see whether they produced the lesions peculiar to the disease anthrax; (3) to ascertain whether one or more of these substances exercise any protective action against the disease, *i.e.*, whether any of these substances previously inoculated into an animal susceptible to the disease rendered that animal immune to a subsequent inoculation of a virulent growth of bacillus anthracis. In this paper two stages only of the investigation are dealt with, namely, the separation of the chemical products of the organism, and the testing of their physiological action.

*Method of procedure.*—For the active growth of the bacillus anthracis two kinds of substances are necessary ; the organism must have proteids to live upon, and mineral salts must also be present. This fundamental fact must be duly regarded in preparing any artificial culture fluid.

From the proteids, the toxic principles are, analogy leads us to expect, formed by the organism.

The question of the proteid to be used was an important one. The best results would, I thought, probably be obtained by using a proteid already existing in the animal body, and consequently the proteids of the serum of blood were chosen. Proteids differ no doubt from each other to a greater extent than we can at present define, and the normal proteids of the blood serum differ greatly from gelatine, the common constituent of culture-fluids. Gelatine does not exist as such in the body, and from the action of digestive ferments upon it we know that gelatine differs so considerably from native proteids as to warrant its exclusion from that class. The products of its decomposition, resulting from the growth in it of the bacillus anthracis, would therefore probably not be the products formed by the bacillus when it grows within the animal body and causes the disease anthrax. Gelatine exists in broths in small quantity, forming the chief nitrogenous (albuminoid) constituent of such extracts of flesh, so that it was not considered advisable to use broth (beef or pork) in the investigation. And there is another objection to beef broth, namely, that it contains certain extractive matters, some of which, creatin for example, have a physiological action of their own, which might vitiate the experimental results of the action of the products of the bacterial growth. My object, therefore, in preparing a culture liquid was to use a *pure* proteid which could be sterilised in solution, and to add to it a certain amount of mineral salts.

The globulin and albumin of the blood serum, when sterilised in solution, would become coagulated and sink to the bottom of the culture

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* The experiments were conducted in the Physiological Laboratory, University College, and I have to express my indebtedness to Prof. Schäfer for the use of his laboratory.

tube, and although the bacilli would (as I have found) disintegrate this coagulated albumin, yet it was thought advisable to have a proteid completely in solution. So the proteids of the serum were changed into alkali-albumin, with the result of forming a solution easily manipulated,—since the bacillus anthracis grows well in a slightly alkaline medium. Serum, in which the proteids had been thus altered, was not however ultimately used, since it contains some sugar and also some extractive matter (a small quantity of urea and creatin), which might have interfered with subsequent chemical manipulation.

The alkali-albumin was therefore precipitated from solution by acid, collected on a filter, and well washed with distilled water. It was then dissolved in a small quantity of alkali by heat, diluted to a certain strength, and the mineral salts added. The salts added were of the same nature and amount as those present in blood serum; according to Hoppe-Seyler th re are present in 1 litre of serum, 4·92 grammes of NaCl, 0·44 of $Na_2SO_4$, 0·21 of $Na_2CO_3$, 0·15 of $Na_3PO_4$, and 0·73 (collectively) of $Ca_3(PO_4)_2$ and $Mg_3(PO_4)_2$. It will be observed that the amount of salts above-mentioned is 6·45 grammes. To every litre therefore of artificial culture fluid this amount of salts was added, with the exception that the addition of $Ca_3(PO_4)_2$, and of $Mg_3(PO_4)_2$ amounted to 0·70 grammes only, namely, 0·5 gramme of the former to 0·2 gramme of the latter. But the soda used in dissolving the precipitate of the alkali-albumin being neutralised by hydrochloric acid, increased the amount of NaCl to 6·3 grammes, instead of 4·92 grammes: so that in each litre of the culture fluid the salts were present in the following proportion:—

| | | |
|---|---|---|
| Of | NaCl | 6·3 grammes. |
| „ | $Na_2SO_4$ | 0·44 „ |
| „ | $Na_2CO_3$ | 0·21 „ |
| „ | $Na_3PO_4$ | 0·15 „ |
| „ | $Ca_3(PO_4)_2$ | 0·50 „ |
| „ | $Mg_3(PO_4)_2$ | 0·20 „ |

The actual procedure adopted is illustrated by the following experiment:—

500 cc. of sheeps' serum were mixed with an equal quantity of 2 per 1,000 NaHO, and placed in the incubator for a few hours. The solution was then gradually heated to the boiling point, and, after cooling, was neutralised and made just acid with HCl. The precipitated alkali-albumin was filtered off, and the precipitate on the filter washed with distilled water twice. The precipitate was then removed, stirred in a sterilised beaker with 500 cc. of 2 per 1,000 NaHO, and gently warmed till all the proteid was dissolved. To this solution was then added 2½ litres of sterilised distilled water, containing per litre the amount of salts already mentioned, and HCl was also carefully added until the solution remained only just alkaline. Such a solution is then clear, except for some undissolved $Ca_3(PO_4)_2$ at the bottom of the beaker, and is of a yellowish colour. It is next placed in sterilised flasks and carefully sterilised. If the solution be now actually boiled some turbidity results, though this does not interfere with the bacterial growth. But no cloudiness occurs if the heating be very gradually performed, or if the liquid is sterilised by repeated steaming without actual boiling.

A culture fluid thus prepared contains pure alkali-albumin, and the mineral salts above mentioned. In the samples used for experiment, the proteid is present in varying quantity according to the dilution practised, namely, from 0·9 to 1·64 per cent. This last per-centage ought not to be exceeded, as the liquid then becomes too turbid on

sterilising. As a rule, from 200 cc. of original blood serum (bullock's or sheep's) 1 litre of clear culture-fluid can be prepared.

Such a culture fluid gives the following reactions :—

1. It is slightly alkaline to test paper.
2. Nitric acid gives a dense precipitate, coagulated by heating.
3. A trace of copper sulphate, and an excess of potash, give a violet colour (ordinary proteid reaction).*
4. If the alkali-albumin be precipitated by alcohol and filtered off, the alcoholic filtrate on evaporating to dryness leaves a residue consistiug of a trace of unprecipitated proteid and of the mineral salts present. From this residue abolute alcohol extracts nothing but a trace of fat.

This culture-fluid I will call "*Artificial serum.*"

*Cultivation.*—From 1½ to 3 litres of this culture-fluid were used in each experiment, usually in test-tubes containing about 18 cc. each. In some experiments the cultivation was done in flasks, but the results were not so satisfactory as when the organisms were grown in the tubes. The bacilli did not appear to grow so well in flasks, *i.e.*, in a large bulk of liquid. This was seen not only by the naked eye, but was also evident from the diminished amount of change which the proteid underwent.

The tubes or flasks were inoculated with anthrax spores, or better still, with a two or three days' growth of anthrax bacilli on gelatine. The *purity* of such anthrax culture was tested before use for experiment and the purity of the culture in the artificial serum was similarly tested after growth in it had become established; all the results hereafter to be described will refer to pure cultures of the organism that had been tested in this way. The *virulence* of the bacilli was also tested on mice, and was found to be uniformly very active. The cultivation was carried out in an incubator at 37° C.; for 7, 10, 12, 14, 21, and 25 days in different experiments, so that the chemical products at these respective periods might be differentially tested.

*Filtration.*—After growth in it of the anthrax bacillus the culture was filtered through Chamberland's filter, and the clear filtrate was tested for organisms by gelatine-plate cultivations, so as to check the efficacy of the filter. The clear culture-filtrate, free from organisms, was then subjected to chemical examination in the manner presently to be described.

## I. The Chemical Products occurring in the Anthrax Culture, and their Separation from one another.

Before proceeding to deal with the methods of extraction and purification of the new substances produced in the cultures, it is important to note what was observed progressing in them from time to time.

Thus, to quote one experiment out of many, 120 tubes each containing about 18cc. of culture-fluid were inoculated with a pure anthrax growth on January 27th, 1890 (Experiment vii.). One tube was tested at the end of seven days (February 3, 1890). The liquid gave a well-marked biuret reaction, *i.e.* a pink colour with $CuSO_4$ and KHO (in excess); with nitric acid it gave a dense precipitate, mostly soluble on

* This reaction shows (as does that with nitric acid) that there is no albumose present in the artificial serum prepared as described. If proteids be boiled with *strong* soda, part of them is transformed into albumoses. No albumose was present in the artificial serum used for cultivation.

heating, but reappearing again on cooling. Both these reactions showed that the alkali-albumin had undergone a change into an albumose. Before growth in it of the anthrax bacillus, the liquid, as previously stated, gave a violet colour with $CuSO_4$ and KHO, and with $HNO_3$ a precipitate coagulated by heat. These reactions after seven days' cultivation, show then that an albumose or albumoses had been formed from the alkali-albumin. At the end of 11 days' growth the culture gave a brighter biuret than at the end of seven days, and a still brighter one at the end of 14 days, when the culture was filtered. The culture-filtrate was distinctly alkaline and gave similar reactions to those mentioned. This experiment, therefore, and as well others not quoted here in detail, distinctly shows that from the alkali-albumin, an albumose or albumoses or peptones were formed. Tested in this way the process is seen to be very similar to that of digestion of proteids by a proteolytic ferment, such as pepsin. This point will be discussed later on.

[If instead of alkali-albumin coagulated proteid be used as a culture medium, the culture-filtrate gives a precipitate on boiling, and the presence of this coagulable proteid may be considered as the first stage of transformation of the insoluble proteid into more soluble products,—as in tryptic digestion. The later stages of the transformation of coagulated albumen by the organism are the same as those undergone by alkali-albumin, only they occur somewhat more slowly.]

To return to artificial serum cultures. At the end of 14 days all the alkali-albumin is not transformed, as the fluid still precipitates on neutralisation. On filtering through porcelain, most of the unchanged alkali-albumin remains on the filter, while the albumoses and other products readily pass through it in solution.

The general plan on which the culture-filtrate was investigated regarded the proteid as so changed by the organism that the alkali-albumin had become altered into other forms of proteid, and that from it other non-proteid bodies in addition, —alkaloidal or not in nature,—had been formed. It was anticipated that the new proteids formed would be precipitable by alcohol; and that the non-proteid bodies (possibly alkaloidal) would be soluble in alcohol. This was found to be the case.

### A. *The Proteids of the Filtrate.*

In separating these, great precautions were taken as regards the application of heat, for the reason that if the proteids were toxic a high temperature, or the prolonged application of a moderate temperature, was likely to destroy or modify their toxic properties. Putrefaction too was guarded against by the repeated addition of small quantities of alcohol during evaporation.

The filtrate was therefore evaporated, either in open dishes at 37°–40° C., or in vacuo at 20°–30°, the vapour being condensed. When reduced to small bulk it was thrown into a large excess of alcohol, whereby most of the proteid was precipitated. This was filtered off, and the filtrate again evaporated, this time to dryness. The residue, extracted with alcohol till nothing further dissolved, was dried and dissolved in a small quantity of water, and re-precipitated by alcohol. By this means the remainder of the proteid was obtained. This last proteid consists of deutero-albumose and some proto-albumose, whereas the first-obtained proteid precipitate is a mixture of a little alkali-albumin, some proto-albumose, and a trace of deutero-albumose. The further treatment of the proteids is as follows: They are well washed with

absolute alcohol, then dissolved in sterilised distilled water and precipitated by alcohol; the process being repeated two or three times until the alkali-albumin is coagulated and remains undissolved, and the final solution consists almost solely of proto-albumose and deutero-albumose. The precipitated proteids are then allowed to stand under alcohol for 4–7 days, or longer; this alcohol is next removed, and the precipitate washed with alcohol and dried. In this way any substance clinging to the proteid and soluble in alcohol is removed, and the proteid obtained in a pure state. The solution of the proteids is then dialysed for over 7 days, and evaporated to dryness in vacuo.

The first proteid precipitate, which is, as has been said, a mixture of alkali-albumin and proto-albumose with a trace of deutero-albumose, gives the following reactions :—

1. It is amorphous and yellowish white, falling in a floculent white precipitate when alcohol is added to its solution.

2. Its solution is brownish yellow, distinctly alkaline to test paper.

3. Nitric acid gives a precipitate partly soluble on heating, and partly coagulated; the precipitate, therefore, consists of alkali-albumin and of proto-albumose.

4. Faint biuret reaction is obtained, with a trace of copper sulphate and excess of potash, and the ordinary violet reaction for proteids, if more $CuSO_4$ be added.

5. Saturation with NaCl causes a dense precipitate. This consists of practically all the proteid in solution, since the filtrate after saturation gives no biuret reaction, and a slight precipitate with excess of acetic acid (showing a mere trace of deutero-albumose). The precipitate obtained by saturation with NaCl is partly alkali-albumin and partly proto-albumose.

The second proteid precipitate from the culture filtrate is a mixture of proto- and deutero-albumose with sometimes a trace of peptone.

1. It can be obtained as an amorphous yellow powder, looking like ordinary peptic albumoses (*e.g.*, Witte's peptone); or, when dried slowly, as a translucent yellowish-brown mass.

2. It is very soluble in water; alcohol dissolves nothing from it.

3. Its solution is strongly alkaline, much more so than that of the first proteid precipitate (alkali-albumin and proto-albumose).

4. It gives a brilliant biuret reaction, as brilliant as that of peptic albumoses.

5. Nitric acid causes a precipitate, soluble on heating, coming down on cooling, &c., showing the presence of proto-albumose.

6. Boiling does not cause a precipitate.

7. Saturation with NaCl causes a precipitate (proto-albumose); but the filtrate contains most of the proteid, since it gives a bright biuret reaction, and a dense precipitate with acetic acid. This is due to deutero-albumose.

8. Saturation with $(NH_4)_2SO_4$ precipitates most of the proteids in solution: in some instances, however, the filtrate gives a faint biuret reaction, so that a small quantity of peptone has been formed, but only in cultures 21–25 days old.

9. The mixture of proto- and deutero-albumose gives the ordinary proteid reactions. The colour, with Millon's reagent, is, however, not a very bright red; it is only a pinkish red, but is, however, distinct.

With this mixture of proto-albumose and deutero-albumose, the inoculation experiments presently to be described were performed. I have called these bodies by the same names as those similar bodies found in peptic digestion (Kühne and Chittenden's nomenclature), since the

chemical reactions are similar, as also are the physical properties. As, however, these albumoses that I am dealing with differ in some respects from peptic albumoses, it would be better to style them anthrax-, proto-, and deutero-albumose. The difference lies chiefiy in the alkalinity of the anthrax albumoses.

This alkalinity is not due to the fact that the albumoses have been formed from alkali-albumin, since albumoses have no power of holding acids or alkalies, as do globulin and albumin when they form acid—or alkali-albumin. Moreover, the alkalinity of the proteid is not slight but great. It is not removed by dialysing the solution of proteid for 4–6 days in running water, and then for 2 days in distilled water. Also, if the proteid solution be made strongly acid with hydric chloride, and then dialysed for over a week, so that all the free acid may diffuse away, the proteid nevertheless remains acid,—as when precipitated by alcohol, washed, dried, and re-dissolved, the solution is found still acid. When precipitated with neutral salts to saturation; ($NaCl$; $(NH_4)_2SO_4$) the albumoses are still alkaline. The alkalinity is not removed by absolute alcohol, by benzene, by chloroform, or by ether. It is therefore something peculiar to the albumose, remaining so closely attached to it that dialysis does not remove it.

If the dry proteid, however, be treated, for 24–48 hours at 40° C., with absolute alcohol made strongly acid with $HCl$ or $H_2SO_4$, a yellow amorphous body is removed from it, having a certain physiological action. I have not obtained sufficient of this body to investigate it thoroughly, but some of its properties will be discussed when the physiological action of the proteid comes to be considered.

However prolonged the treatment of the proteid with acid alcohol, even if this be followed by prolonged dialysis, the proteid still remains either alkaline or acid: so that it must be concluded that whatever substance it is which gives strong alkalinity to the albumose, it is one firmly united to it, forming indeed an integral part of it. This alkalinity seems explainable by the results of the investigation of the chemical products of the culture which are soluble in alcohol, as follows:—

## B. *The Alcoholic Extract of the Culture.*

This may be obtained after separation of the albumoses, by evaporating the alcoholic filtrate to dryness, at 40° C., or in vacuo, and extracting the residue with absolute alcohol. By again filtering this, traces of albumose and the mineral salts are left behind, and the alcohol which passes through the filter contains the products of the bacterial growth which are soluble in alcohol.

The above method is, however, not so rapid or successful as the following, which is one commoniy used in toxicological investigations. The culture-filtrate is mixed with about one-third its bulk of rectified spirit and saturated with pure, dry, potassium carbonate ($K_2CO_3$). The liquid separates into two layers and the superficial alcoholic layer is removed by a separating funnel. More alcohol is then added to the watery liquid saturated with the $K_2CO_3$, more of this salt is also added, and the alcohol removed. The process is repeated three times, and all the alcohol thus removed is mixed together. It is of a clear golden-yellow colour. It is next evaporated to dryness at 40° C., and the residue extracted with absolute alcohol several times until nothing more dissolves. The alcohol* leaves undissolved some albumose and some

* It is necessary to use 99 to 99·5 per cent. alcohol for the purification of this body.

potassium carbonate; and dissolves out a yellow body. This yellow substance is, however, not pure: besides a trace of albumose and of $K_2CO_3$, it contains very minute traces of leucin and tyrosin. It is, therefore, further purified by evaporating to dryness at 40° C., dissolving the residue in absolute alcohol, and repeating the process till a clear alcoholic solution is obtained. On standing in the cold this solution deposits the last traces of leucin, which clings to the sides of the vessel. The solution is then once more evaporated, the residue dissolved in alcohol and preserved in alcoholic solution for further use. The final product gives no colour reaction with copper sulphate and potash, thus showing the absence of any albumose; and gives no effervescence with acid, showing the absence of potassium carbonate.

The properties of this body soluble in alcohol are as follows:—

1. It is very readily soluble in water and amylic alcohol; and soluble with ease in absolute alcohol (99°/₀), in which it is fluorescent.

2. It is insoluble in pure (alcohol-free) ether, in chloroform, and in benzene.

3. In alcoholic solution it is precipitated unchanged by a large excess of ether, causing a white turbidity which falls to the bottom of the beaker as a yellow liquid mass. It is, however, not completely thrown down by ether, so that I at first thought there were two substances present, one precipitated, the other not precipitated, by ether. But as these substances give exactly the same chemical reactions, and had the same physiological properties, I have concluded that they are identical.

4. The substance is strongly alkaline and readily forms salts with acids:—Thus,—

(*a.*) The *sulphate of the base* is prepared by making its aqueous solution slightly acid, evaporating to dryness in vacuo or at 40° C., washing off any excess of acid or uncombined base with absolute alcohol, drying, dissolving the crystals in distilled water, and evaporating to dryness,—the process being repeated several times. The crystals of the sulphate are needle-shaped, becoming on repeated crystallisation larger and prismatic. They vary in length: the smallest being microscopic the largest about a line in length. In a thin layer these crystals are white, but in mass they appear yellowish.

(*b.*) The *hydrochlorate* crystallises in opaque white prisms and needles, which are hygroscopic.

(*c.*) The *oxalate of the base* is readily prepared by adding a saturated solution of oxalic acid in absolute alcohol drop by drop to the alcoholic solution of the base till the liquid is strongly acid. The crystalline precipitate which falls is filtered off and washed with absolute alcohol till the washings are colourless. The crystals are then dried and dissolved in water, and re-crystallised as in the preparation of the sulphate. The crystals are oblong and branching, yellowish in colour; in re-crystallisation they form prisms and needles.

The oxalate prepared was an acid oxalate, the sulphate a basic salt; they are both insoluble in absolute alcohol, but dissolve in weak alcohol. From these salts the base can be readily regained. Thus the watery solution of the acid oxalate was made strongly alkaline with potassium carbonate, alcohol was then added, and the mixture, after shaking, was saturated with potassium carbonate. The alcohol dissolves the base and floats on the top of the saturated potassium carbonate solution. The alcoholic layer is removed, evaporated to dryness, and extracted with alcohol until the solution contains no potassium carbonate. In this way the pure base can be prepared.

5. It is a yellow, or brownish-yellow amorphous substance, solid when perfectly dried in vacuo, but somewhat hygroscopic; so that when exposed to the air it tends to become liquid. If kept in the dried state it undergoes decomposition at the end of a fortnight or three weeks, gradually losing its alkalinity, and becoming more and more acid. It has, therefore, to be preserved in alcoholic solution. It is slightly volatile, so that when its watery solution is mixed with alcohol it may in part be distilled over in vacuo at a temperature of 20°—30° C.; and recovered from the distillate (mixed with some leucin) by the potassium carbonate method. Only a small portion, however, passes over, and this has a powerful sweet aromatic smell (? due to a volatile fatty acid) which the pure substance does not possess. The aroma of the pure base is faint and aromatic. The process of distillation appears to tend to decompose the base, for the portion which does not distil soon becomes acid on exposure to the air in the dried state.

6. As to the reactions of the base in watery solution the following are obtained:—

| *Reagent.* | *Result.* |
|---|---|
| Phospho-tungstic acid - - | Copious yellow precipitate. |
| Phospho-molybdic acid - - | Ditto ditto. |
| Potassio-mercuric iodide - - | No precipitate or turbidity. |
| Mercuric chloride (saturated solution). | Turbidity, becoming a slight precipitate. |
| Phospho-antimonic acid - - | Slight turbidity when greatly in excess. |
| Platinic chloride - - - | Turbidity and slight precipitate. |
| Millon's Reagent - - - | A yellow precipitate which becomes red on heating. |

These reactions, with the properties previously described, show the base to be an ALKALOID. Its further chemistry must be left to a future communication; at present I am engaged in making an elementary analysis of it.

## II.—Physiological Action of the Chemical Products.

When the bacilli of anthrax are experimentally injected into the animal body, there occurs a local lesion at the site of inoculation, followed by a general infection of the animal. After death, and in mice (which are the only animals I have used), the lesions commonly found are a greater or less amount of clear œdema with congestion at the site of inoculation; a dark and congested spleen, which is usually but not always enlarged, and the presence of the bacillus anthracis in the lesions and the blood of the animal.

In investigating therefore the physiological action on mice of the chemical substances formed outside the animal body by culture of the bacillus, attention has been given to ascertaining whether, in the mice experimented on, there is repetition of the local œdema and congestion at the site of inoculation, and of the enlargement and congestion of the spleen, which are observed when the bacilli themselves have been injected.

## A. *Physiological Action of the Albumoses formed by Bacillus anthracis.*

The albumoses used were the mixture of proto- and deutero-albumoses previously described. Their physiological action on mice was investigated when they were strongly alkaline, and as well after their acidulation and dialysis. In either case the material to be inoculated was dissolved in a few minims of sterilized distilled water, and the syringe employed was duly sterilized before use. The mice were in all instances inoculated subcutaneously in the back.

### (a.) *Action of the Alkaline Albumoses.*

This is best shown in the following experiment :—

| Mouse. | Weight, in Grammes, of Animal. | Amount of Albumoses inoculated. | Number of Grammes Albumoses per Kilo. of Body Weight of Experimental Animal. |
|---|---|---|---|
| A. | 29 | 0·35 gramme. | 12·07 |
| B. | 29 | 0·20 | 6·90 |
| C. | 26 | 0·10 | 3·84 |
| D. | 25 | 0·05 | 2·00 |
| E. | 22 | 0·05 | 2·27 |
| F. | 22 | 0·05 | 2·27 |

*A.*, having received 0·35 gramme, became ill soon after the inoculation, the illness gradually increasing. In 18 hours the mouse had a great swelling all over back, spreading from site of inoculation; the swelling was indeed so great that the animal could not walk well. There was no paralysis. The animal remained in much the same condition, becoming weaker and the œdema increasing. It aborted in about 36 hours. By the end of 42 hours it was worse, and became comatose in 66 hours, when it was evidently dying. The post-mortem (Sunday intervening) was made 24 hours later. The swelling of the back had disappeared, and no local œdema was found. The *spleen* was dark and congested, but not enlarged. The other organs presented no morbid appearance to the naked eye.

*B.*, which received 0·2 gramme, was not evidently ill soon after inoculation. In 18 hours, however, it showed slight bulging at site of inoculation; but it had no other evident symptoms until the morning of the 12th day, when it was found comatose and dying. It was then killed with chloroform. *Post-mortem :* No local œdema was found, but at the site of inoculation there was a skin-sore (healthy-looking) the size of a sixpence. The *spleen* was small; the *kidneys* large and congested, but the other organs appeared normal.

*C.* (which received 0·1 gramme), and *E.* and *F.* (each receiving 0·05 gramme) were indisposed soon after inoculation, and definitely ill in 18 hours, when there was bulging at the site of inoculation. Their illness persisted for 42 hours, after which the animals perfectly recovered.

*D.* was killed 18 hours after inoculation to learn what were the temporary lesions produced by a small dose (0·05 gramme, or 2 grammes per kilo. of body weight). There was found, at the site of inoculation, well marked local œdema with congestion. The *spleen* was greatly enlarged, dark, and congested, but dry on section. Two gelatine

tubes were inoculated with splenic pulp, but no growth appeared in the tubes during 4 days' incubation.

The above experiment shows that inoculation of mice with the mixture of alkaline anthrax- proto- and deutero-albumose gives results as follows:—

1. A local œdema in 18 hours. This œdema is very great with a large dose, smaller with a medium dose.

2. The animals develop symptoms of illness soon after the inoculation, the rapidity of onset and the severity of these depending on the amount of material inoculated.

3. Death is, if it occurs, always delayed; it is producible only by a large dose of the albumoses, and it takes place by way of coma.

4. The albumoses produce in some instances enlargement of the spleen, but in no case were micro-organisms obtainable in culture from the spleen pulp. If the spleen be not enlarged it may nevertheless be dark and congested.

### (b.) *Action of the Albumoses after Extraction with acid alcohol and dialysis.*

The same stock of albumoses used in the experiments just described was treated with acid alcohol and dialysed as in the manner previously recorded. After dialysis the proteid was precipitated by alcohol. It remained slightly acid and was used for inoculation after it had been dried.

| Mouse. | Weight of Animal, in Grammes. | Amount, in Grammes, of Material inoculated. | Number of Grammes of Material per Kilo. of Body Weight of Experimental Animal. |
|---|---|---|---|
| A. | 23 | 0·313 | 13·6 |
| B. | 21 | 0·156 | 7·4 |
| C. | 20 | 0·078 | 3·9 |

*A.* became in one hour after inoculation a little sluggish, but temporarily recovered. The next morning (*i.e.*, 22 hours after inoculation) this mouse was found comatose, the only sign of life being its slow breathing. The breathing became thenceforward more and more irregular until death, 25 hours after inoculation. *Post-mortem:* There was enormous local œdema spreading from the site of injection (the right back) all over the abdomen and the front of the chest on the right side. The œdema was clear and brownish, and there was slight congestion also. A few bubbles of gas were present in one part. The *spleen* was not enlarged but was dark and congested. Attempt at culture of splenic pulp on gelatine afforded no growth of organisms during six days' incubation.

*B.*, which received 0·156 gramme, became ill soon after inoculation; it was very sluggish in two hours, but gradually improved and was more lively at the end of six hours. In 22–30 hours it was still somewhat sluggish, and had now evident bulging at the site of injection. It however took its food well and soon rapidly recovered, the bulging also disappearing.

*C.*, which received 0·078 gramme, was not noticeably affected by the inoculation; it was apparently well and lively 23 hours thereafter. At this time an additional 0·045 gramme of the albumoses was injected under the skin of the left side of the back,—the first injection having been on the right side. The animal now became ill at once, and its illness rapidly increased during the next hour. Three hours after inoculation the animal was comatose and apparently dying. The coma next became profound, the only evident sign of life being slow and irregular breathing. Death occurred in a little over six hours from the second injection. The *Post-mortem* showed enormous œdema at the site of the first inoculation spreading over the right side of abdomen; at the site of the second injection there was only slight œdema. The peritoneal cavity contained an excess of fluid. The *spleen* was not enlarged, but it was dark and congested. The other organs appeared normal.

This experiment with the dialysed and acid albumoses shows:—

1. That it is as toxic as the alkaline anthrax albumoses. And further it appears:—

2. That the lethal dose of either alkaline or acid albumoses is a very large one, a mouse of average size requiring between 0·3 and 0·35 gramme, or more accurately from 12·7 and 13·6 grammes albumoses per kilo. of body weight of the animal to produce death.

3. That a more toxic action is produced by injecting at intervals two non-lethal doses than by administering at one injection an amount equal to the combined doses. Thus the sum of the doses which killed *C.* in the last experiment quoted is 0·123 gramme, whereas *B.* with a dose of 0·156 gramme, administered at a single injection, was not killed, although it was rendered ill.

It has been already mentioned that from the alkaline albumoses from which absolute alcohol, benzene, chloroform and ether dissolved nothing, a small quantity of an amorphous yellow non-proteid substance was obtained by extraction with acid-alcohol. This extract, having been first evaporated to dryness, dissolved in water, and neutralised, was now injected into a mouse weighing 21 grammes. No symptoms having appeared in 18 hours, the animal was killed. *Post-mortem*:—There was found at the site of inoculation congestion over a small area, and around this a larger zone of œdema. *The spleen* was not enlarged, but was dark. *The kidneys* were congested. The other organs appeared normal.

In a second similar experiment, 0·018 gramme of this substance having been obtained from about 1·5 grammes of anthrax albumoses, it was injected into a mouse weighing 14 grammes. This animal became ill and sluggish in 10 minutes, and grew gradually worse in 5 hours. It recovered somewhat in 10 hours, but remained unwell for about 36 hours, after which complete recovery took place, a small skin-sore at the site of inoculation remaining.

This substance therefore, as also the alkaloid to be presently referred to, produced on administration *in small doses*, definite symptoms and lesions the same in kind as those occurring after inoculation of the albumoses themselves. Nevertheless the toxicity of the albumoses cannot be ascribed to the *mere presence*, so to speak, of this body in mixture with the proteid, since in the last experiment, for example, the most prolonged extraction with acid alcohol only removed from the proteid a quantity (0·018 gramme) of the body now in question, which proved insufficient to cause death, whereas the quantity (1·5 grammes) of albumoses from which it was extracted would have sufficed (as experiment has shown) to kill five mice of average weight.

That some toxicity must be ascribed to the albumoses as such is shown indeed by the fact that boiling their solution diminishes and, if the boiling be prolonged, practically destroys their poisonous qualities. Thus, a solution of 0·128 gramme of the dialysed proteid having been heated in a water bath at 100° C. for 7 minutes was injected into a mouse weighing 20 grammes,—a dose, namely, of 6·4 grammes per kilo. of its body weight. The animal was not, however, apparently affected by this injection; no local œdema or skin-sore developed during five days, but on the sixth day the animal was found dead. On *post-mortem* examination there was no local œdema. The spleen was small, not congested. There was no peritoneal effusion, and the organs were normal to the naked eye.

In another experiment 0·3 gramme of albumoses was heated for 20 minutes in a sealed tube in a water-bath. When injected into a mouse weighing 22 grammes, it produced no symptoms for three days. Then at the site of injection there appeared some local œdema, and a furless patch of skin: no sign of illness at this time or during the 30 days that the animal was watched.

The physiological action of the anthrax albumoses may therefore be summed up thus :—

1. They produce in mice a local œdema, and in large doses they cause in the end death. In some cases the spleen is enlarged, in others it is merely congested. Peritoneal effusion may also be present.

2. The symptoms observed are sluggishness, coming on soon after inoculation; followed (when the dose is large) by gradually increasing coma, with slow and irregular breathing, and finally death. With small doses the sluggishness lasts for several hours, but in the end the animal rapidly recovers.

3. These effects are to be ascribed to the albumoses since they are not developed, if the solution of the proteid be boiled for 20 minutes before it is inoculated into mice.*

## B. *Physiological Action of the Alkaloid formed by Bacillus anthracis.*

Experiments were made with the alkaloid free from albumoses and from mineral salts, free also from tyrosin, and containing only a microscopic trace of leucin. The alkaloid, after having been dissolved in a few minims of sterilized distilled water, was injected, like the albumoses, under the skin of the back.

A small dose of the alkaloid injected into a mouse weighing 22 grammes made the animal very ill in 5 minutes. In 30 minutes it had become very sluggish and hardly moved when pushed. The sluggishness increased during the next 3 hours, and from the third to the seventh hour the mouse lay huddled up, with its fur ruffled, and eyes shut. At the end of 18 hours the animal was still very weak and ill. It was killed now with chloroform. *Post-mortem:* There was found at the site of injection congestion and œdema over an area the size of a shilling, and around this was a still larger area of clear œdema. The *spleen* was very large, dark, congested, and dry. Cultivations of the splenic pulp in two gelatine tubes showed no growth of organisms during 10 days' incubation. The *kidneys* were congested. The other organs appeared normal.

* It is impossible to avoid noticing the similarity of behaviour to heat of anthrax albumoses and of cobra-poison. Both require prolonged boiling for destruction of their poisonous qualities, and differ altogether in this respect from the jequirity proteids the toxicity of which is, as I have shown, completely destroyed by a momentary heating to 85° C.

A small dose of the alkaloid therefore produced in this preliminary experiment local œdema, enlargement of the spleen, and sluggishness increasing to a state of stupor, which however was partially recovered from before the animal was killed.

The following experiments show the effects of the alkaloid in different doses :—

| Mouse. | Weight of Animal, in Grammes. | Amount, in Grammes, of Alkaloid inoculated. | Number of Grammes Alkaloid per Kilo. of Body Weight of Experimental Animal. |
|---|---|---|---|
| A. | 21 | 0·037 | 1·76 |
| B. | 21 | 0·0375 | 1·8 |
| C. | 21 | 0·0375 | 1·8 |
| D. | 24 | 0·0548 | 2·3 |
| E. | 26 | 0·0822 | 3·2 |
| F. | 28 | 0·10 | 3·6 |
| G. | 22 | 0·15 | 6·8 |

*A.* having been inoculated with 37 milligrammes became very ill in 5 minutes afterwards. In another 10 minutes it was worse, lying huddled up with its eyes shut and fur ruffled. Its illness increased during 2 hours, but next morning (18 hours after inoculation) this mouse was slightly better though still very sluggish. The sluggishness persisted for over 42 hours, after which the animal rapidly recovered.

*B.* and *C.* (each inoculated with 0·0375 gramme) had symptoms similar to *A.*, although not quite so pronounced. Recovery took place in over 42 hours.

*D.* (which received 0·0548 gramme) became sluggish soon after inoculation, and remained ill for 24 hours, when a second dose of 0·05 gramme was injected. The animal now became very ill in a few minutes, with sluggishness increasing to coma and death in 5 hours and 20 minutes after this second injection. *Post-mortem :* There was found great subcutaneous œdema at the sites of both injections. The *spleen* was very large, dark, and congested; its capsule roughened. The other organs were apparently normal. Two gelatine tubes inoculated with splenic pulp failed in affording growth of organisms during 6 days' incubation.

*E.*, which received 0·0822 gramme, became ill soon after inoculation, and continued so for 24 hours, when a second dose of 0·05 gramme was injected. Severer illness soon developed and increased to stupor and coma. The animal was killed 4½ hours later for comparison with *D.* *Post-mortem :* There was found enormous subcutaneous œdema, spreading from the sites of both injections, and as well congestion. The *spleen* was enlarged, dark, and congested. The other organs appeared normal. Cultivations of splenic pulp did not afford any growth of organisms during 6 days' incubation.

*F.* (which received 0·1 gramme) became very ill a few minutes after the injection. Its illness and sluggishness increased for six hours, until the animal became quite motionless, in a state of coma, though breathing regularly. There was by this time great bulging over the back at the site of injection. The animal, although apparently dying at the end of 6 hours, nevertheless recovered during the night, and after the lapse of 24 hours had almost completely recovered from its symptoms, slight sluggishness only remaining. At the site of injection there was a furless patch of skin which was adherent to the abdominal

muscles. This mouse was now (24 hours after inoculation) killed. *Post-mortem:* At the site of injection there was found slight subcutaneous œdema outside the limits of the furless patch of skin. The *spleen* was not enlarged, but was dark and congested. The other organs appeared normal.

*G.* (which received 0·15 gramme) became ill in five minutes, and in the course of one hour had bulging at site of injection so great as to cause the animal to move with difficulty. There was no actual paralysis. Its fur was ruffled and its eyes shut. Death which occurred in coma in 2 hours and 20 minutes was preceded by muscular twitchings and a few attacks of shivering. *Post-mortem:* There was found extending from the site of injection enormous clear yellow subcutaneous œdema implicating the back and the side of the abdomen, where the œdema was about $\frac{1}{8}$th inch thick. It was surrounded by a zone of deep congestion and of patchy redness (? ecchymoses). The *Post-mortem* was made 10 minutes after death. The small veins were found thrombosed. The *spleen* was slightly enlarged, dark, congested, and dry. The *kidneys* were congested. The other organs appeared normal.

No definite inference is to be drawn from the differing effects of different amounts of alkaloid injected, since an identical dose may produce symptoms of different intensity in healthy mice of the same weight; these animals varying a good deal in their power of resistance to this material. Nevertheless the lesions and symptoms produced by the alkaloid are upon the whole definite enough, namely,—

1. It causes subcutaneous œdema and local congestion which is rapid in appearance, and is roughly in proportion to the amount of alkaloid injected. If the experimental mouse recovers, the site of this œdema is marked by a furless patch of skin, and in most instances by the development in a few days or a week of a skin-sore which is healthy-looking. This ulcer is evidence of the considerable damage the alkaloid has done to the subcutaneous tissues.

2. The alkaloid produces enlargement of the spleen, sometimes well-marked, sometimes slight; and in addition the organ is congested.

3. The symptoms come on sooner after injection of the alkaloid than after injection of the albumoses. And they are more severe with large doses. The sluggishness increases to stupor, coma, and death.

4. Successive inoculation of non-lethal doses of the alkaloid proves in some instances fatal.

5. The alkaloid, while producing symptoms and lesions similar to those induced by the albumoses, is certainly more poisonous. A smaller dose of it produces more rapid death.

### *Summary of Results and Conclusions.*

1. The bacillus anthracis when grown in a liquid medium containing pure alkali-albumin and mineral salts, digests the proteid, forming proto- and deutero-albumose and a trace of peptone,—bodies similar as regards chemical reactions to those formed in peptic digestion. But this "digestion" goes a stage further than the peptic, an alkaloid being produced, as well as small quantities of leucin and tyrosin. So far then as the formation of the albumoses and peptone is concerned, the process corresponds to peptic digestion; but in the presence of leucin and tyrosin there is analogy on the other hand to tryptic digestion.

2. The important characteristic of the albumoses is their strong alkalinity in solution; an alkalinity which cannot be removed by the ordinary solvents for alkaloids, nor by dialysis. It can, however, be changed to acidity by the addition of acid; and in any case the albumoses

are precipitated by alcohol or by saturation with sodium chloride or ammonium sulphate in an alkaline or acid condition. The alkaline albumoses do not, as does the alkaloid, become acid on keeping in the dried state.

3. This strong alkalinity of the albumoses is probably due to the formation from them of the powerful base (alkaloid) that has been described. In fact the alkaloid represents, so to speak, one of the final stages of the "digestion" of the alkali-albumin by the bacillus anthracis. The several stages are probably these :—Proto-albumose is first formed, then deutero-albumose, and finally the alkaloid. So that the alkalinity of the albumoses may be explained, not by the mere presence of the free alkaloid side by side with the proteid but by the presence of the alkaloid in a more or less *firm chemical combination* with the proteid molecule. The alkalinity may indeed represent the alkaloid molecule in the stage of budding off from the albumose molecule. This consideration may explain the toxicity of the albumose as such, for when the latter is brought into contact with living tissues (as is the case when it is subcutaneously inoculated) the alkaloid may become developed out of the albumose by the agency of the tissues themselves, in just the same way as in the experimental culture medium it is produced from the albumose by agency of the bacillus itself. The slow development of toxicity of the proteid is at any rate in favour of this view.

4. The anthrax albumoses and the alkaloid produce similar lesions and symptoms, but with different degrees of severity. The albumoses act slowly and kill only when injected in large amounts. The alkaloid acts quickly and kills in a much smaller dose. Both substances, however, produce a local subcutaneous œdema and congestion, with in many instances enlargement or congestion of the spleen. With the albumoses, the spleen is not always thus affected; but with the alkaloid it has been so in all the experiments performed. Indeed in some of the post-mortems on mice dead after injection of the alkaloidal poison, the lesions have been impossible to distinguish by the naked eye from those of typical anthrax. For instance, there is the great subcutaneous œdema and the enlarged and congested spleen ; the only difference between this condition and that induced in anthrax being that no bacilli are to be found in the spleen, as was 'shown by failure to obtain growth of organisms in gelatine tube cultivations of the splenic pulp.

I have not yet investigated the production of fever by these substances; but this subject, along with the chemical examination of the lesions of anthrax in sheep, and as well the question of obtaining prophylaxis by use of these substances, comes next in order for inquiry.

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The credit of first finding an albumose as the outcome of the life processes of bacillus anthracis rests with Mr. H. Hankin, who, last year, in a short paper in the British Medical Journal,* announced such discovery. Mr. Hankin did not, however, describe any toxicity as belonging to the albumose, nor did he give details of the reactions of the body. Professors L. Brieger and C. Fränkel have since published two papers in the Berliner Klinische Wochenschrift† dealing with the chemical products of Löffler's bacillus of diphtheria, and the chemical products also of other pathogenic micro-organisms. They describe, under the name of "toxalbumin," a toxic proteid body produced by

* Vol. II., 1889, p. 810.

† March 17 and 24, 1890, Nos. 11 and 12, pp. 241 and 268.

these bacteria. They also state that from the organs of rabbits dead of anthrax they have isolated a "toxalbumin." The details given by them of this anthrax toxalbumin are, however, too scanty as yet for any accurate conclusion to be arrived at as to its precise nature. The reactions given by them for their diphtheria "toxalbumin" do not relegate it to any of the known classes of proteids: taken together they seem to indicate that the "toxalbumin" is an albumose or a mixture of albumoses. The use, however, of peptone in this culture-fluid renders it difficult to decide this, as the method adopted by Brieger and Tränkel would precipitate the unchanged "peptone" of the culture-fluid along with the "toxalbumin." Peptone, (*i.e.*, commercial peptone, which consists largely of proto- and deutero-albumose) when used in the culture-fiuid greatly complicates, as I myself have found, the examination of the chemical products of the life processes of the micro-organism. The term "toxalbumin" would seem totally unnecessary; indeed on future investigation the body so designated will probably be found to be a mixture of albumoses with possibly an alkaloid.

It would seem not improbable that the majority of pathogenic organisms change the proteids they act upon much in the manner that the bacillus anthracis has been shown to do in the experiments recorded in this paper. As to this, however, future research will of course decide.

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